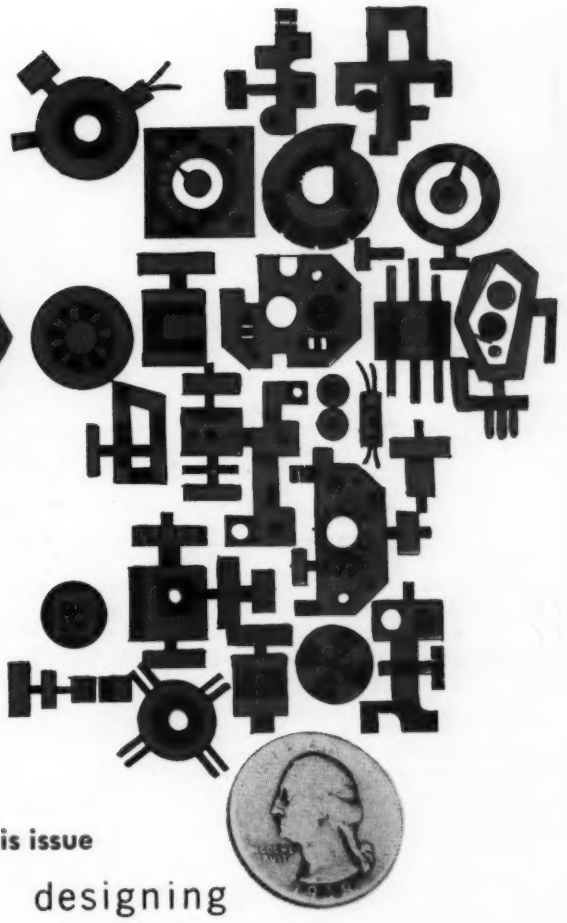
ELECTROMECHANICAL

components & systems | DESIGN

AUGUST 1960



in this issue

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for
miniaturization

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The University of Michigan
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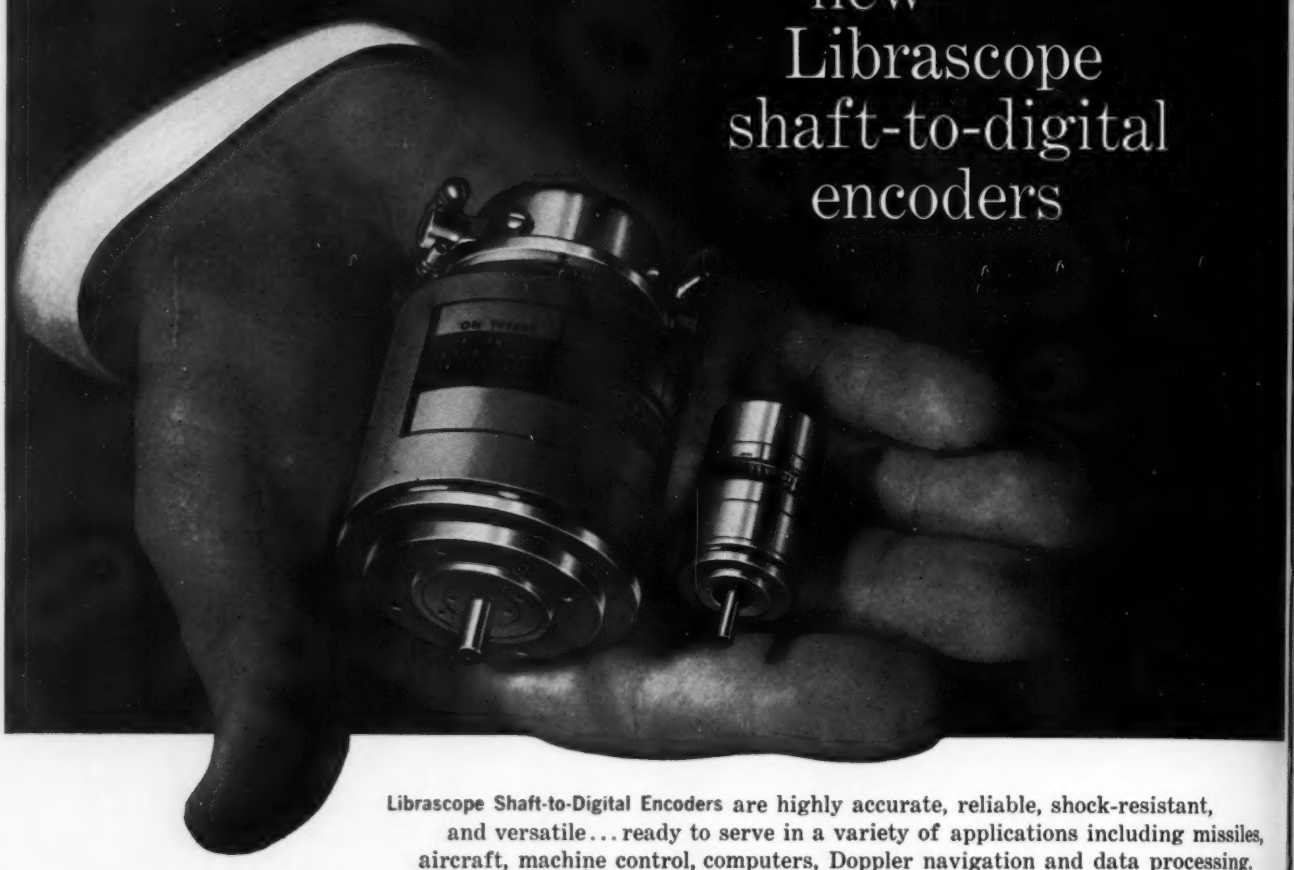
NO OTHER LINE SO COMPLETE · 38 NEW ENCODERS · 38 NEW ENCODER MODELS · SIZE 8 MAGNETIC · SINE/COSINE · GRAY · SELF-DECODING

new Librascope shaft-to-digital encoders



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MODEL NO. 807

FEATURES:
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SPECIFICATIONS:
Output Code: natural binary
Resolution: (per input shaft turn) 128 counts
Full Scale Capacity: 7 bits*
Speed: operating from 0 to 10,000 rpm
Life Expectancy: 20,000 hours at 4,000 rpm; 4 x 10^9 revolutions
Starting Torque: 0.1 in-oz. max.
Diameter: 2"
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Weight: 5 ounces

*ALSO AVAILABLE IN 13, 17, AND 19 BIT CAPACITIES.

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MODEL NOS. 787 & 793

FEATURES:
Low torque, low inertia, long life, high reliability, withstands severe environments.

SPECIFICATIONS:
Output Code: natural binary
Resolution: (per input shaft turn) 128 counts
Full Scale Capacity: 7 bits, 13 bits
Speed: operating 200 rpm, slew 600 rpm
Life Expectancy: 2 x 10^6 revolutions at 200 rpm
Starting Torque: 0.5 oz-in. maximum
Diameter: .750"
Weight: 3 ounces

other popular Librascope encoders

Code	Model no.	Full scale capacity	Resolution per input shaft turn
Binary	773	13 bits	128 counts
	0-773	oil-filled unit for increased life	
Binary	710	10 bits	1024 counts
Binary	707 (707D*)	7 bits	128 "
	713 (713D*)	13 bits	128 "
	717 (717D*)	17 bits	128 "
	719 (719D*)	19 bits	128 "
	0-713	oil-filled unit for increased life	
Self-Decoding Binary	740	10 bits	1024 counts
B/C/D	723 (723D*)	2,000 counts	200 "
	724 (724D*)	20,000 "	200 "
	733 (733D*)	3,600 "	200 "
	734 (734D*)	36,000 "	200 "
	735	360,000 "	200 "
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	758 758-S**	4 quadrants per turn	8 bits per quadrant + limit 1
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ELECTROMECHANICAL components & systems DESIGN

The Sourcebook of Design · Ideas in Applied Electromechanics

AUGUST 1960 • VOL. 4 NO. 8

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BPA Circulation for June over 29,000

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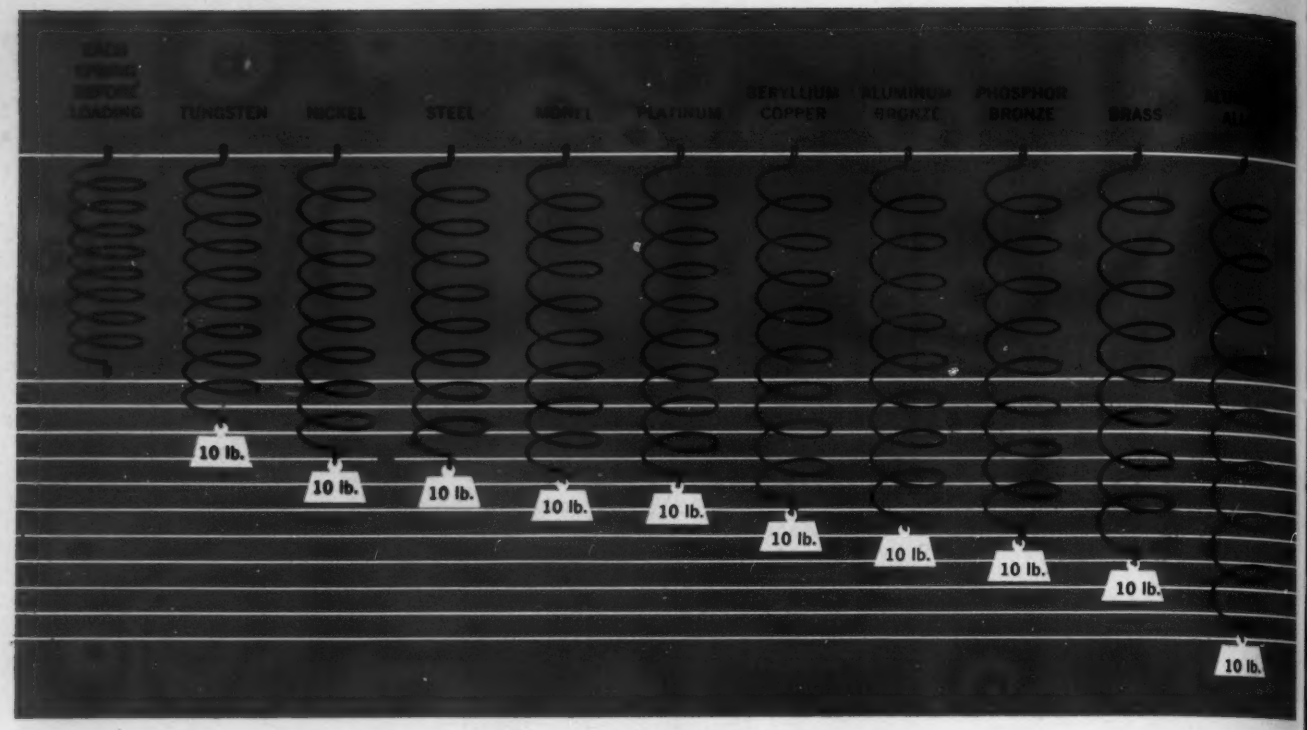

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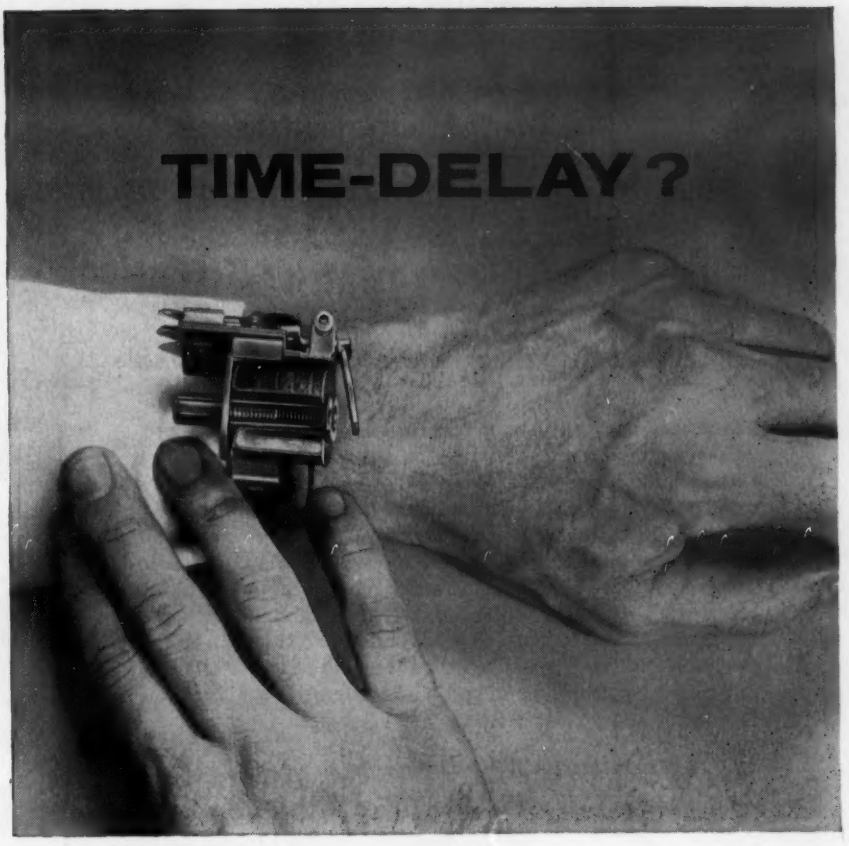

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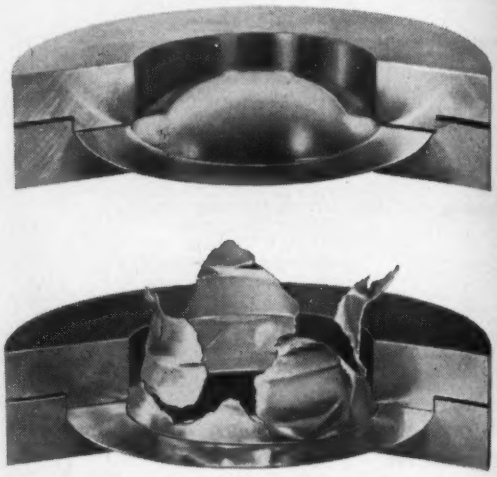

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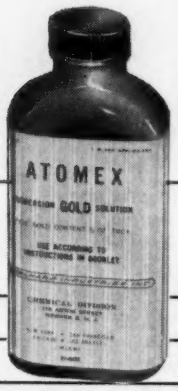

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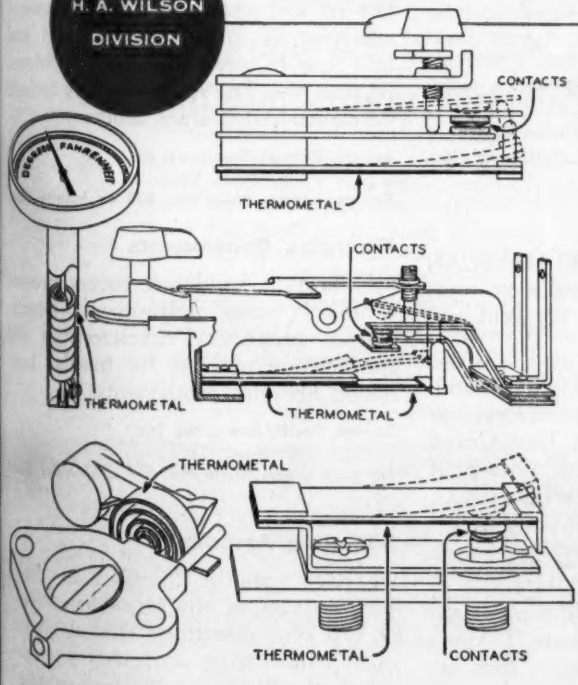

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LETTERS

New York, N.Y.

Back in October, 1959, you ran an article by M. Glasberg on *Predicting Response to Modulated Inputs from Response to Sine Wave Inputs,* which claimed to present a "simpler, accurate, and a cheaper" method of servomechanism testing than the Servoscope. The article described a method of applying the 2-sideband frequencies of a modulated carrier to the device to be tested, but using two responses which are combined mathematically to produce the standard envelope frequency and phase response.

Theoretically, this method is correct. However, it is also a very impractical and cumbersome method compared with the servo approach.

The statement on the Servoscope is clarified by the following reasons:

1. Instead of a single modulation frequency being checked at each point, each point now requires both sidebands.

2. A special interpolating oscillator is required for an input signal. For instance, a frequency of 0.1 cycle now would require 400.1 cycles and 399.9 cycles (400 cycle carrier).

3. The author says "a minimum of regular laboratory equipment is needed". Yet, to measure the phase angle to any accuracy, a fairly good phasemeter would be necessary.

4. The author admits his method cannot be used to test servo motors (probably one of the most popular components available). This factor alone should destroy the usefulness of this method in 75% of all applications.

5. This method is of no use at all in complete overall open loop measurements (involving servo motors, tachs, servo valves, modulators, demodulators) and is not capable of the more important closed loop measurements.

The Servoscope prevents none of these shortcomings and at the same time, it is a self contained unit.

Donald Jillson, Ass't. Dir.
Public Relations
Smith, Winters, Mabuchi, Inc.
Agents for Servo Corp. of America

I have to admit that you caught me picking on the Servoscope, but only because it is recognized as a leader in the field of servo analyzers. I suggest, however, that your arguments in favor of servo analyzers are somewhat overzealous.

Your first two points are questionable because the sinewave response can be measured at any arbitrary frequencies. The only requirements are that the frequencies must be close enough together to produce smooth curves and that the measurements must be made at frequencies above and below the carrier frequency. Once the smooth curves are obtained, they can be used to predict modulated response by following the directions in the article.

The third point is also questionable because the phase shift can easily be measured by superimposing the input and output sinewaves on the same scope. Superimposing the sinewaves would require either a dual beam scope or an electronic switch. Actually, if accuracy is not too critical, the phase shift could be obtained by measuring the phase at the start of first the input sinewave and then the output sinewave using the carrier signal as an external sweep. This last scheme would eliminate the electronic switch. Even at worst, however, only a scope, an audio oscillator, and an electronic switch would be required. You must admit that this equipment is more common than a Servoscope, at least at present.

Points four and five I agree with and mentioned in the article, but there are other ways of measuring response. For example, the response to a step input or square wave input will produce a fairly good measure of the dynamic parameters. Also, open loop measurements are not too simple even with a Servoscope if dc drift is experienced and the system contains integration elements.

A last point, which you did not mention and which was emphasized in the article, is that the Servoscope is hard to use if the system output signal contains large harmonic, quadrature, or noise components. Under these same conditions measuring the sinewave response is much simpler and more accurate.

Martin Glasberg
Contributing Editor

. . . I find ELECTROMECHANICAL DESIGN to be the best and most comprehensive publication in my field and also the most scarce.

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Phycisist
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Atomics International

. . . There is a wealth of information in every issue of ELECTROMECHANICAL DESIGN that I have seen.

Arthur Francis Menton
Servo Corporation of America

. . . I have reviewed a borrowed copy of the December issue of ELECTROMECHANICAL DESIGN and find it contains an excellent source of reference articles very much in line with my present work.

John W. Galysh,
Research Engineer
New Devices Laboratories
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Thermistors

24 page book describes what thermistors are and what they do, gives several examples of how they are used and tells how to solve thermistor problems. Ratings of a line of thermistors include resistance-temperature tables.

Source: Fenwal Electronics, Inc.
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Specification handbook covers present technical limits, advantages, terminologies, production characteristics and specification outlines for tubular laminated fiberglas components.

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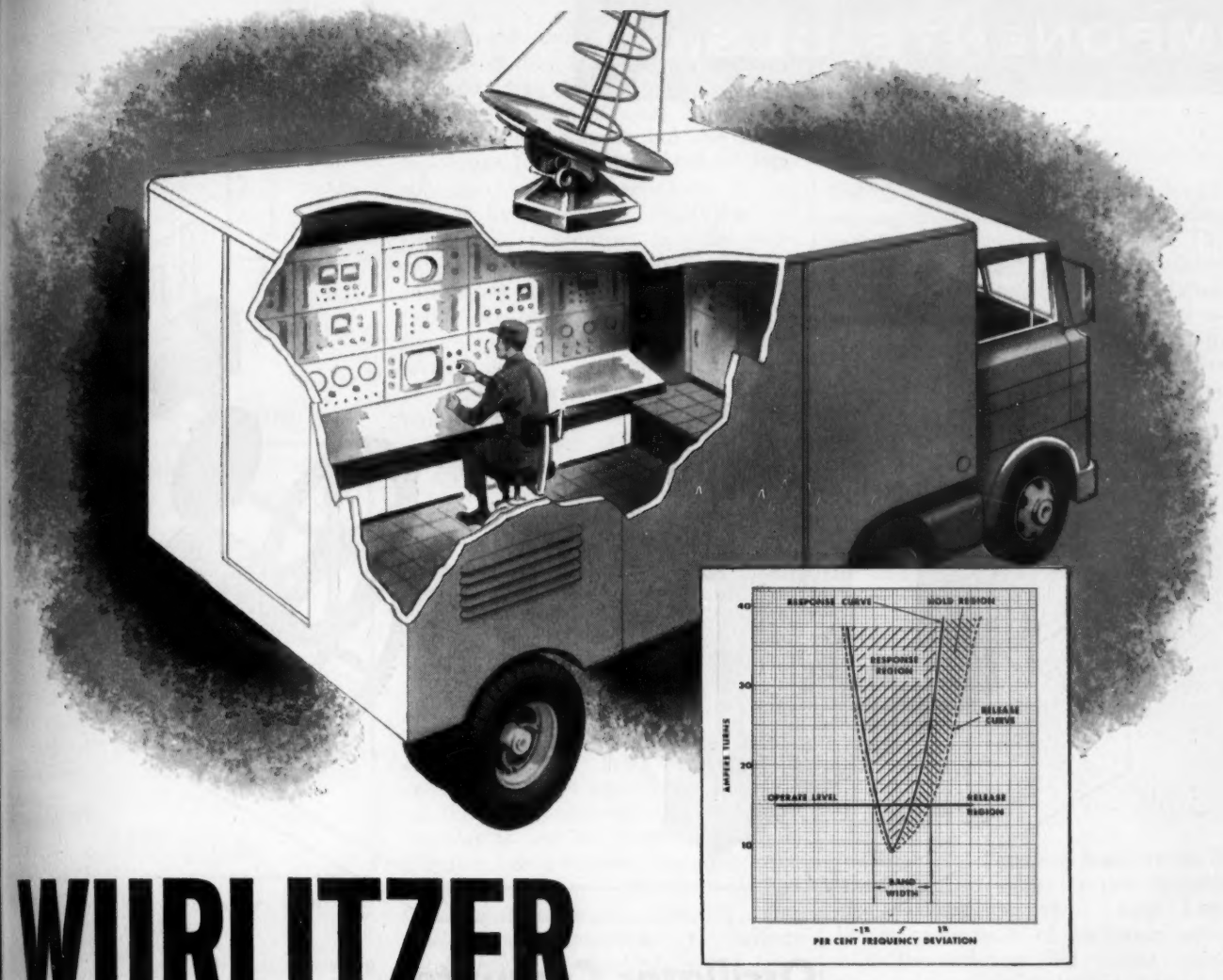

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- Speed Control
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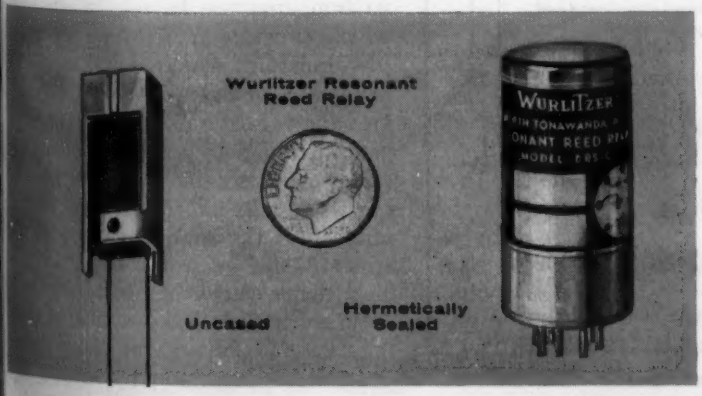

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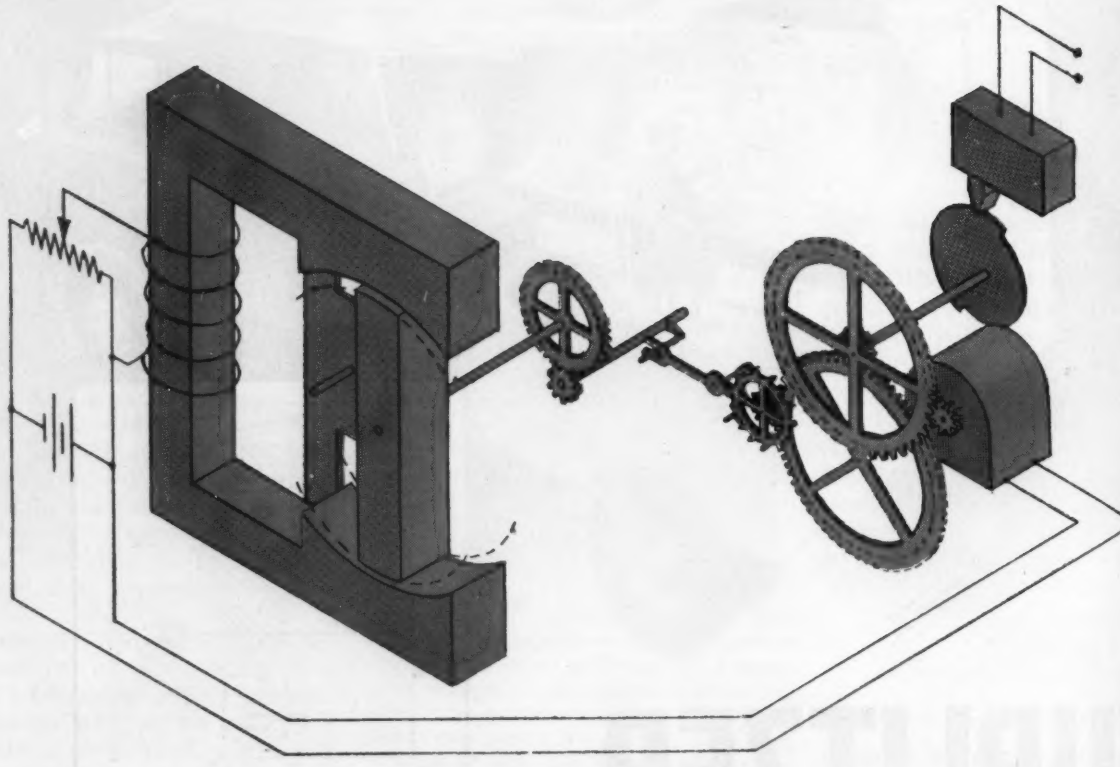
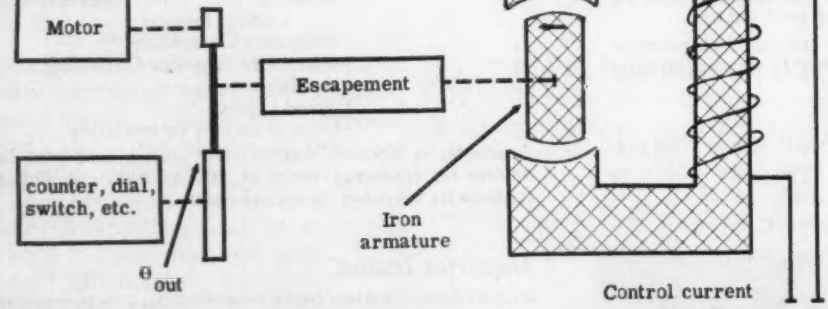


Oscillator Computer

Electromechanical Resonant Circuit With Variable Spring Constant



For a single coil in the field control, the resonant frequency of the armature is

$$f_r = (\tfrac{1}{2}\Pi\ (K_s/I)^{\frac{1}{2}} \approx K_s^{\frac{1}{2}} \quad (I = \text{constant})$$

The force between magnetic poles is

$$F = \phi^2/2\,\mu\,A \cong \phi^2 \cong i^2 \cong K_s$$

therefore

$$f_r \cong (K_s)^{\frac{1}{2}} \cong (i^2)^{\frac{1}{2}} \cong i$$

and the equation for output shaft rotation is

$$\Theta_{OUT} \cong \int i\ dt$$

For several coils in the field control

$$f_r \cong \Sigma\ (N_1\ i_1 + N_2\ i_2\ \ldots .)$$

and

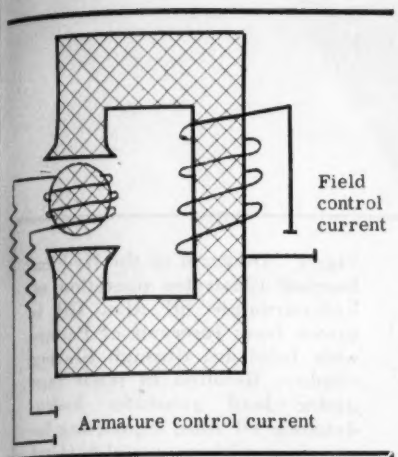
$$\Theta_{OUT} \cong \int (\Sigma\ Ni)\ dt$$

Fig. 1 Oscillator computer with iron armature.

Combining a simple clock movement with an electric meter movement, both products of long and highly skilled instrument traditions, William H. Barr of Hingham, Mass. has invented a multi-function computing element that takes full advantage of the low cost and high accuracy of these two components.

Fig. 1 illustrates Barr's design in its simplest form. In this configuration, the balance wheel and hair spring of the clock mechanism are replaced by an iron armature in a magnetic field, which provides a restoring force on the armature similar to that of the hairspring on the balance wheel, causing the armature to oscillate. The natural frequency of this oscillation is proportional to the field control current. Thus, in effect, the control current varies the spring constant of the system.

A major factor in obtaining high accuracy in the device is that of making the oscillation frequency independent of amplitude by shaping the



Force on armature $\cong$
$$\Phi_f \times i_a \cong i_f \times i_a$$
therefore
$$f_r \cong (i_f\, i_a)^{1/2}$$
and
$$\theta_{OUT} \cong \int (i_f\, i_a)^{1/2}\, dt$$
For several windings on the armature and field
$$f_r \cong [(\Sigma N_{1a}\, i_{1a} + N_{2a}\, i_{2a} \ldots) \times (\Sigma N_{1f}\, i_{1f} + N_{2f}\, i_{2f} \ldots)]^{1/2}$$
and
$$\theta_{OUT} \cong \int [(\Sigma N_a\, i_a)(\Sigma N_f\, i_f)]^{1/2}\, dt$$
for a permanent magnet field
$$f_r \cong (\Sigma N_a\, i_a)^{1/2}$$
and
$$\theta_{OUT} \cong \int (\Sigma N_a\, i_a)^{1/2}\, dt$$

Fig. 2 Oscillator computer with coil armature.

magnetic field so that the restoring force increases linearly with armature displacement. Such refinements are basic practice in meter movement design. Moreover, errors in the meter movement tend to be averaged out since amplitude of the oscillation covers a wide range.

In this configuration, several windings can be used on the field control resulting in a resonant frequency output proportional to the summation of the separate coil quantities—the output frequency is directly proportional to the total amp. turns of the input coils.

Figure 2 shows a variation of the oscillator computer in which the armature is an oscillating coil, similar to that of a moving coil galvanometer. In this case the output would be proportional to the square root of the current product of the armature current and the field current.

Several windings could be put on both the field control and the armature control to mechanize more complicated computing operations.

Thus, by choice of configuration and application, the output may be pulse or rotational rates proportional to a current, the sum of several currents, the square root of one current, or the square root of the product of sums of several currents, or the output may be shaft rotations proportional to the time integral of these quantities.

The computing elements illustrated in figures 1 and 2 are limited to operations where the input signals are positive quantities. A configuration that performs these same operations given plus, minus or zero input quantities is shown in Fig. 3.

APPLICATIONS

Used with proper transducers, the oscillator computer can be controlled by almost any function; pressure, weight, velocity, radiation, etc. Some of the more obvious applications of the device are: as electric current integrators or totalizers, remotely controlled timers or programmers, precise, variable-speed, remotely controlled motor governors; to indicate total weight of material carried by a conveyor belt in any length of time; to integrate the quantity of fluid flow through a pipe, or provide the rate of flow where the equation

$$\int (xy)^{1/2}\, dt$$

must be solved; to indicate distance travelled in aircraft where the inputs are airspeed and component of wind velocity; for general use in controllers or computers; as an anologue-to-digital converter and computer where the pulse rate is proportional to any of the above functions; to solve for the square root, etc., of various functions.

To appreciate the versatility of the device, consider how often the above functions must be performed and how much instrumentation is required at present to accomplish them.

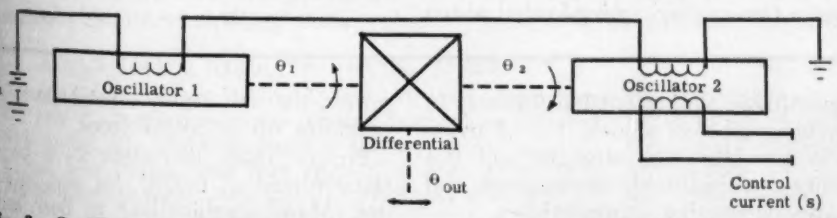
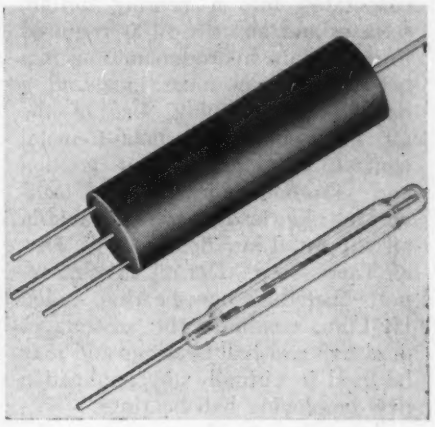


Fig. 3 Oscillator computer configuration that accepts plus, zero or minus input signals. Voltage source V_1 causes oscillators 1 and 2 to operate at the same speed in opposite directions. With no control current applied the output shaft is stationary, although the oscillators are operating at optimum speed. The output shaft will then run at a rate and direction proportional to the control currents.

Reed Relays

Use of a short pole piece with a longer moving reed permits higher operating speeds of magnetic reed switches. The hermetically sealed, glass encapsulated switch is surrounded by an operating coil to provide SP-ST normally-open relay action. Switch itself is 3¼" long by 0.215" dia. and single contact relay with coil is approximately 9/16" diam.



Capable of handling loads up to 15 watts and 250 volts, the unit operates at a maximum current of 1 amp. Load life at one-quarter of maximum rating is in the order of 200 million operations. Minimum operating power is approximately 100 milliwatts.

In addition to single contact relays, other types of packaging are available including assemblies consisting of several switches surrounded by a single operating coil and clusters of relays on printed circuit boards. Struthers-Dunn, Inc., Pitman, N.J.

Write No. 157 in Box on Inquiry Card

WORTH FILING

Laminated Plastics

12 page manual contains a quick-reference chart of characteristics for 21 commonly-used laminate grades. Information on how to specify and order laminated plastics includes: thumbnail description of high-pressure laminates; the difference between minimum/maximum property values and average values; where and why laminate property values differ from the specification properties listed for metals and step-by-step instructions on how to use the reference chart.

Source: Taylor Fibre Co., Norristown, Pa.

For your copy: Write No. 418 on Inquiry Card

NEW BEARING DESIGNS

SELF-LUBRICATING BEARING

Rotation on Hydrodynamic Oil Film Permits a 20,000 Hour Life

Lifetime recirculatory oil system, incorporated into a bearing design, releases and absorbs oil as required to maintain a hydrodynamic oil film between a steel inner race and a babbitt-lined bushing. Use of the oil film eliminates metal-to-metal contact, thus minimizing friction and vibration. Permawick, a self-wicking lubricant, is the sealed-in oil supply. Tann Bearing Co., Div. of Tann Corp., Detroit, Mich., reports that their new bearing, called Hy-Film, combines the advantages of sleeve and ball bearings and may be used in virtually any application now employing ball bearings.

According to the company, the Hy-Film is the first off-the-shelf bearing engineered to support a shaft on a hydrodynamic oil film. The principle, however, has been tested on several million fhp motors manufactured within the past five years. More than 35 motor manufacturers now use Permawick lubricant and individually engineered bushings, slingers, etc. to produce a bearing system with a hydrodynamic oil film and lifetime lubrication. Research with similar bearings in integral motors established that a packaged bearing in this size is more economical than the assembly of individual components, thus stimulating the development of the Hy-Film bearings.

Units are scheduled for volume production by September, 1960 with bores from eight to 40 millimeters. Prices will be comparable to medium grades of ball bearings. Limited quantities are now available for research and development. Curves showing the life expectancy at various loads and speeds for each size of the new bearing are available from the manufacturer.

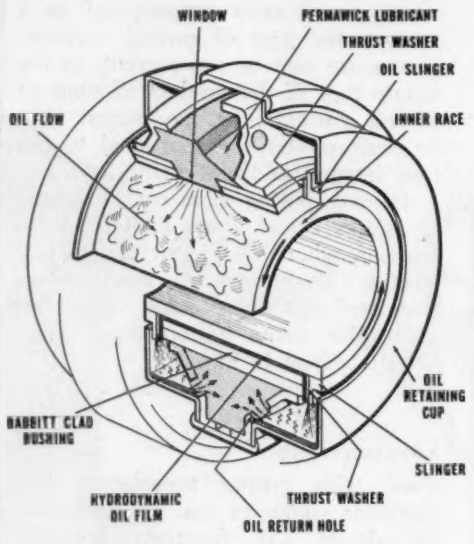


Fig. 1 Diagram of the Hy-Film bearing illustrates operation of hydrodynamic oil film. Oil is drawn from reservoir of Permawick lubricant through bearing window. Rotation of inner race under load generates hydrodynamic oil film, supporting inner race without metal-to-metal contact. Oil forced to bearing ends by film pressure lubricates thrust washer. On leaving washer, oil is picked up by slinger and forced to oil retaining cup. It is then reabsorbed by Permawick through oil return hole with impurities filtered out by fibers. Hy-Film bearing is said to be virtually free of vibration and noise and resistant to humid and gritty atmospheres. Recommended operating temperatures range from −25 to 200F.

Write No. 156 in Box on Inquiry Card

JEWELLED BEARINGS

Design Eliminates Vibrations and Absorbs Shock

Designed for all types of indicators, gages and electrical measuring equipment, Uniflex shock absorbing, jewelled bearings are said to eliminate all vibrations of the pointer hand and protect equally against axial and radial shock. Radial and axial pressure are equal, but if desired, the radial pressure can be reduced to as little as half of the axial pressure.

Pivot radius can be reduced, resulting in less friction. Pivot point radii of 15-20 microns with a rotating mass of 250-300 milligrams have been achieved. Radii of 5-10 microns and less are said to be possible.

The jewel is rigid and can move only if under pressure from the outside. Design incorporates a tapered bushing and a free-of-play, spring-loaded piston which automatically positions the jewel in dead center when the outside pressure is relieved. Guilding faces of the taper and the piston are highly polished and checked for flatness with a microscope.

A version of the bearing, with a minimum height of only 0.32 inches, was designed especially for exposure meters built into cameras. Foster Supplies Co., Chicago, Ill.

Write No. 158 in Box on Inquiry Card

NEEDLE THRUST BEARING

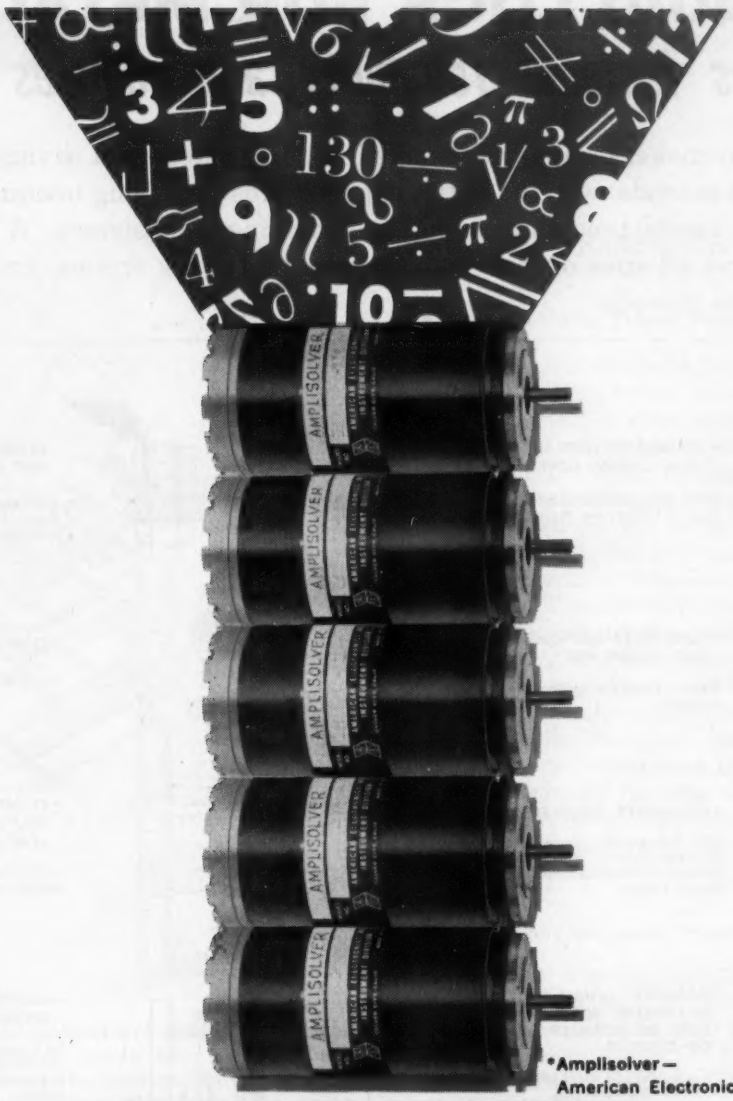
Nylon Retainer Reduces Friction

Improved type of needle thrust bearing, developed by the Kaydon Engineering Corp., Muskegon, Mich., employs a nylon retainer that reduces undesirable sliding friction inherent in previous all-steel models. Use of nylon also provides high strength and stability combined with non-magnetic and noise dampening characteristics.

Thrust capacity is said to be equal to or greater than that of all-steel bearings and permissible operating speeds are said to be greater. Extensive laboratory and field testing have proved the unit highly efficient at temperatures up to 350 degrees.

Needle roller diameters have been standardized at 0.078″ for the entire line. Many combinations of bore and outside diameter sizes are available. In addition to its usual applications, the bearings can replace thrust washers in a wide variety of uses.

Write No. 165 in Box on Inquiry Card



*Amplisolver—
American Electronics' new Amplifier/Resolver Module

RESOLVED

YOUR MOST CRITICAL NEEDS IN COMPUTING RESOLVER CHAINS

However complex your problem, American Electronics' Instrument Division has the engineering and manufacturing capability to resolve the equation. Advanced designs incorporate the proven performance of AEI amplifierless resolvers and Amplisolvers* for such applications as true heading indicators, great circle navigation and coordinate converters, and data transmission systems. Inherent reliability, complete interchangeability, and maximum stability over a given temperature range—typical characteristics of AEI computing resolver chains—assure high transformation ratio, minimum phase shift, and functional errors of .05% or better across the chain. Electrical data below shows two typical AEI resolvers used in computing resolver chains. Please write for detailed analysis and discussion of your needs.

AMPLIFIERLESS RESOLVER—MODEL 11R59F-91F

Primary: Stator. **Input:** 10 volts. **Test:** 10 volts. **Frequency:** 400 cps. Z_{RO} **Rotor Impedance (ohms):** Stator open circuited, 54K tuned. Z_{SO} **Stator Impedance (ohms):** Rotor open circuited, 90K tuned. **Total Null Vltg.:** .015. **Max. Error:** .1%. **Transformation Ratio:** .600 ± .001 R/S. **Phase Shift:** 0 ± .1°.

AMPLISOLVER—MODEL 15RA55E-11D

Primary: Stator. **Input:** 10 volts. **Test:** 10 volts. **Frequency:** 400 cps. **Amplifier Power Supply:** 28 ± 1 volt, regulated. **Input Impedance (ohms):** 100K min. Z_{RO} **Output Impedance (ohms):** 270 + j400. **Total Null Vltg.:** .015. **Max. Error:** .05%. **Transformation Ratio:** 1.000 ± .001 R/S. **Phase Shift:** 0 ±.1°.

AMERICAN ELECTRONICS, INC.

INSTRUMENT DIVISION
9503 WEST JEFFERSON BLVD., CULVER CITY, CALIFORNIA
TELEPHONE: UPTON 0-5581 • TWX CVR-CY-4023

CIRCLE NO. 12 ON INQUIRY CARD

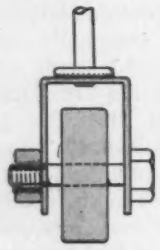
THE LIQUID LOCK FOR METAL PARTS

. . . improves fastener reliability and reduces costs!

LOCTITE sealant makes ordinary fasteners into lock fasteners at savings of 40%-70%. Locking action extends over the entire engaged area providing unequalled resistance to vibration . . . ends breakdowns due to loosening of fasteners. A single drop of LOCTITE replaces all sizes of lock nuts, lock washers, lock screws, jam nuts, staking and interference threads.

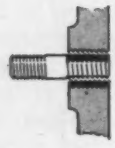
– ELIMINATES LOCK WASHER OR SELF-LOCKING SCREW

Makes ordinary screws into lock screws. Several times the holding power at savings of $20/M.



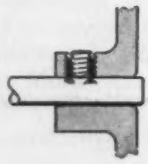
– ELIMINATES SELF-LOCKING NUT OR JAM NUT

Locks non-seated nuts anywhere along the length of thread.



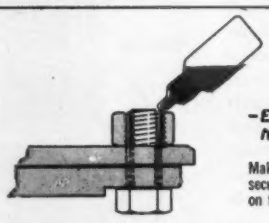
– ELIMINATES INTERFERENCE FIT

Locks studs securely . . . locking action develops after stud is in place . . . allows easy-driving Class 2 threads. End stripped threads, broken studs, damaged castings.



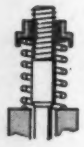
– ELIMINATES DOUBLE SET SCREWS, SELF-LOCKING SET SCREWS, JAM NUTS ON EXTENDED SET SCREWS OR STAKING

LOCTITE-treated set screws cannot vibrate loose . . . end nuisance service calls.



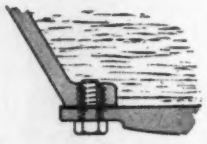
– ELIMINATES SELF-LOCKING NUT OR LOCK WASHER

Makes any nut a lock nut. Saves 40%-70%. Holds securely where lockwashers fail. Does not depend on tightening torque for locking action.



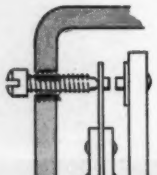
– ELIMINATES SPECIALS OR STAKING

Makes any threaded part self-locking.



– ELIMINATES BLIND HOLE TAPPING, SPECIAL LEAK-PROOF FASTENERS

LOCTITE locks and seals threaded parts against vibration and high-pressure fluids.



– ELIMINATES SELF-LOCKING SCREW OR JAM NUT

Get the right setting the first try . . . no backlash. LOCTITE provides the proper amount of drag to hold adjustment securely. Permits repeated adjustments.

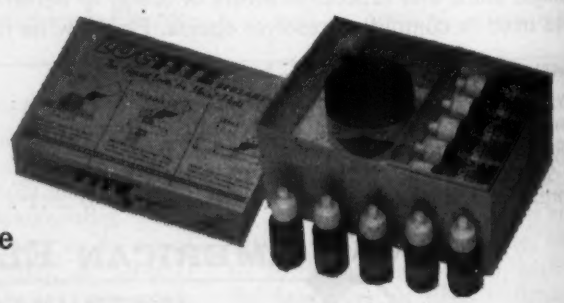
LOCTITE Sealant is easy to apply . . . simple to automate

Labor savings are obtained when several days supply of threaded parts are treated by tumbling with LOCTITE Sealant. Treated parts store for days, lock only when assembled. Smaller quantities may be tumbled by hand in polyethylene bags. Parts may be individually treated using applicator nozzle on LOCTITE bottle or by using continuous feed tube. Parts may be treated *after* assembly, LOCTITE wicks into threads by capillary action.

LOCTITE is a thin liquid that hardens into a tough heat and oil-resistant seal when confined between closely fitting metal parts. It requires no heating or mixing . . . does not air dry. LOCTITE comes fully prepared . . . stores for years . . . hardens only when treated parts are assembled. Ten grades provide any desired torque to all sizes and types of fasteners. LOCTITE-treated fasteners may be removed with ordinary tools . . . fasteners may be re-used.

LOCTITE Kit No. 10-10

Contains 10 grades of Loctite sealant specially put up to assist engineers in determining proper grade of Loctite in product development and for general experimental work. By selection of proper grade, the designer can apply a pre-determined amount of locking torque.



Write for literature and free sample capsule

LOCTITE® SEALANT

AMERICAN SEALANTS COMPANY • 109 WOODBINE ST., HARTFORD 6, CONN.

CIRCLE NO. 14 ON INQUIRY CARD

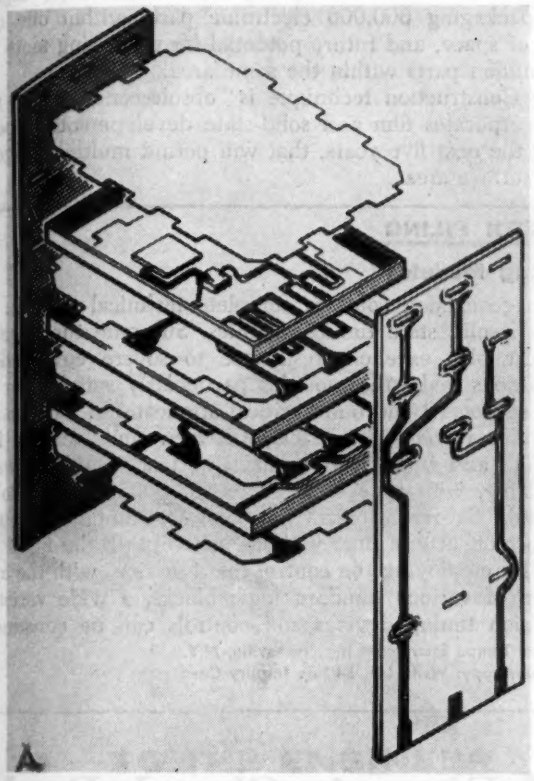


Fig. 1 Tiny Sylvania microminiature module performs function of conventional printed circuit board many times its size. An "exploded" view of the microminiature module shows three basic parts used to form the module: a wafer element a spacer element and an interwiring board. Wafer element maintains a complete functioning circuit stage on a surface less than one-half in. square and 1/100th inch thick. Entire stage is hermetically sealed at one time by the tiny fused spacer element which provides protection from the atmosphere and from neighboring circuits.

"PANCAKE" TRANSISTOR

Wafer-Thin Units Triple Printed Board Capacity

Sylvania Electric Products Inc. has announced the "Pancake" construction, a new concept in transistor packaging, which "will result in a line of miniaturized transistors, one-tenth the size and weight of conventional units." Dr. William J. Pietenpol, Vice President and general manager of Sylvania's Semiconductor Division, said the new construction, developed for the latest microminiaturized circuitry, makes possible smaller and lighter electronic equipment including airborne communications and computer systems.

Sylvania's "Pancake" exploits the advantages of a proven electronic component, the transistor, in a package that offers maximum strength, versatility, and heat dissipation. Conventional transistors (TO-5) use a square or tall outline, approximately .250-inches high, Dr. Pietenpol explained. In the "Pancake," the height dimension has been reduced to one-twentieth of an inch, resulting in a wafer-thin semiconductor package with extreme ruggedness, reliability, and ease of manufacture. In addition, the diameter of the new package (.250-inches) is approximately 25 per cent less than conventional units.

MINIATURIZATION FOR PRINTED CIRCUITRY

For insertion directly into printed circuit boards, "Pancake" transistors may be the "ultimate development" in miniaturization, because their tops will be almost flush with the boards, according to Dr. Pietenpol. In this application, transistors smaller than the "Pancake" design are not presently practical, he said, "because transistor leads cannot be placed closer on circuit boards presently available. Thus, in addition to tripling the density capabilities of today's printed circuit boards, our 'Pancake' design shifts the focus to other components as limiting factor in achieving greater printed board component density."

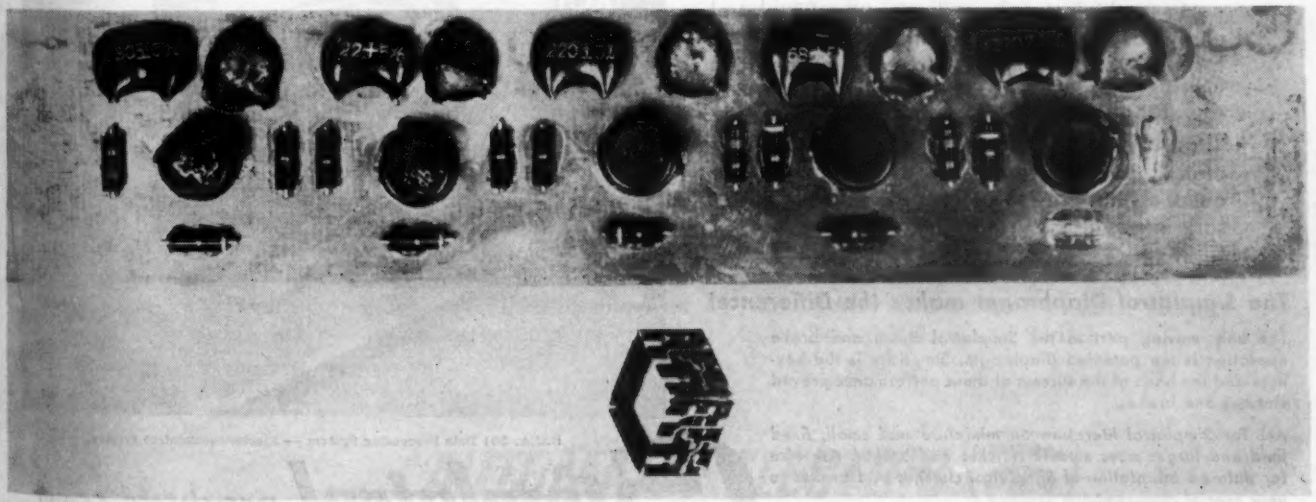


Fig. 2 Interconnecting stacked wafers through the vertical, silk-screened interwiring boards increases the number of circuits in substantially less space. The function of a conventional printed circuit board six in. long and 1½ in. wide can be carried out by a six-wafer Sylvania module ⅜ in. high and less than a half-in. square. Relative sizes of the printed circuit board and module are shown above.

An outstanding feature of the new design, the Sylvania executive stated, is its welded vacuum-tight seal which assures a leak-rating better than 10^{-9} cubic centimeters per second, without the use of sealing materials.

First application of the new construction is in micromodules—tiny building blocks of electronic circuitry. These units, scarcely larger than an aspirin tablet, contain a substantial number of component parts. "For use in micromodules, Sylvania is presently adapting the 'Pancake' construction to its germanium alloy PNP and NPN transistors. Within a few months, we shall begin making PNIP drift transistors, and diffused-base germanium and silicon mesa transistors," Dr. Pietenpol revealed.

DESIGN ADVANTAGES

"The Sylvania module will accommodate both present microcomponents and future solid-state and molecular circuits, and mixtures of both, on an economical, reliable and maintainable basis,", according to Mr. G. J. Selvin, Sylvania's manager of micro electronics. Mr. Selvin summarized the module's advantages:

- The wafer contains sufficient active area for a functioning stage of circuitry.
- Each circuit stage is hermetically sealed.
- There is stage-to-stage interconnection without wires, and total assembly plug-in is provided through a module interconnecting board.
- Construction and seal materials are capable of operations at extremely high temperatures.
- Construction and assembly methods provide the capability for economical, automated mass production.
- Construction technique provides immediate capacity for packaging 600,000 electronic parts within one cubic foot of space, and future potential for packaging more than 30 million parts within the same area.
- Construction technique is "obsolescence-proof", since it incorporates film and solid-state developments, expected over the next five years, that will permit multiple stages on one surface area.

WORTH FILING

Timing Modules

16 page catalog contains complete technical data on controlled solid state timing modules. Sub-miniature size and weight plus excellent resistance to severe environmental conditions make the modules particularly suitable for missile, spacecraft and other critical applications. Basic module provides a precise time delay between application of input voltage and turn-on. Both fixed and adjustable types are available, with time delays from 0.00005 seconds to 300 seconds. Set-reset control line allows instantaneous turn-on or turn off at any time without interrupting the input voltage. By employing the control line function, with the application of various standard logic blocks, a wide variety of precision timing devices and controls can be constructed.

Source: Tempo Instrument Inc., Hicksville, N.Y.
For your copy: Write No. 540 on Inquiry Card

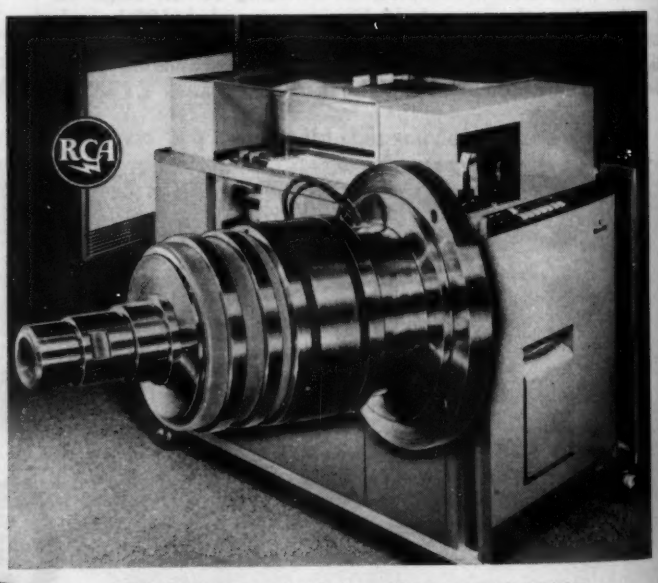
RCA Selects Simplatrol Electric Clutch Brake

CONSISTENCY – SMOOTHNESS – QUIETNESS

These are the reasons that R. C. A. engineers gave for selecting a Simplatrol CB-62 electric clutch-brake unit for use in its new electro-mechanical printer.

In this high speed application, the Simplatrol unit feeds the paper — and indexes it accurately for printing. Specially developed in cooperation with R. C. A. engineers, the Simplatrol unit gives "remarkable consistency".

In the tape drive section of the unit, the Simplatrol clutch-brake delivers a smoothness and quietness not previously available, and so necessary in business machines.



R.C.A. 501 Data Processing System — Electro-mechanical Printer

The Simplatrol Diaphragm makes the Difference!

The only moving part in the Simplatrol clutch and brake operation is the patented diaphragm. Simplicity is the keynote and the basis of the success of these performance-proved clutches and brakes.

Ask for Simplatrol literature on miniature and small, fixed field and larger sizes electric clutches and brakes. Ask also for data on adaptation of Simplatrol clutches and brakes to your special requirements.

Simplatrol products corp.
24-9 SALISBURY ST., WORCESTER, MASS
Representation in Key Industrial Areas

CIRCLE NO. 15 ON INQUIRY CARD

TO THE ENGINEER

who likes his switching gift-wrapped

If you want your control functions prewired, hermetically sealed in a neat package, tested out, and as ready as instant coffee, you're listening to the right people.

Because AE has a gift for wrapping up relays and stepping switches in tidy control packages of your design—or ours, if you prefer.

For instance, the control package illustrated houses an AE Type 45 Rotary Stepping Switch wired to multiple-pin headers for direct plug-in (and we supply the properly oriented socket mounting plate). This particular job has 462 connections, and could just as readily be equipped with MS connectors for insertion in matching cable plugs.

The point is, we've been wiring telephone switchboards and automatic control devices for years, and have the technique down pat. So pat that it would probably cost you less to let *us* do the job.

Besides, AE engineers are past masters at designing complex switching circuits. You can leave it to them, if you wish, to dope out the least expensive way of accomplishing the most sophisticated switching.

How about letting us in on *your* control problem? Just write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois. Also ask for Catalog 4083: "Hermetically Sealed Relays and Switches."

AUTOMATIC ELECTRIC GENERAL SYSTEM

Subsidiary of

GENERAL TELEPHONE & ELECTRONICS

CIRCLE NO. 11 ON INQUIRY CARD

e·m·r

13 BIT ALL-MAGNETIC Shaft-Position Digital ENCODER

In any environment, in all applications, ASCOP magnetic encoders have proved to be rugged and tough. Our customers say that nothing compares to them for endurance and perfect performance under the worst conditions.

Now ASCOP has taken the same unique magnetic readout principle and incorporated it into a neatly miniature, ruggedly simple design to read out shaft positions to one part in 2^{13}. Parallel output is in binary code and total count is reached after 64 turns of the precision shaft and gearing. Lead-lag head arrangements assure that external decision making circuitry is minimized. The new ASCOP encoder operates in either direction and can be read out at rest or on-the-fly at speeds up to 10,000 rpm with equal facility. Since the only contacting parts are shaft and gearing, these are the only factors affecting life.

Condensed Specifications

Total Count:	2^{13} achieved in 64 turns of input shaft
Size:	2¼" dia. x 3⅛"
Code:	Binary with lead-lag heads
Output:	Parallel
Weight:	16 ozs.
Inertia:	70 gm-cm²
Breakaway Torque:	0.05 in. oz.
Max. RPM:	10,000 rpm
Expected Life:	20,000 hrs. at 4000 rpm (expected bearing and gear life)

Brochure, price and applications notes on request

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CIRCLE NO. 69 ON INQUIRY CARD

OIL SEAL

Enclosed Sealing Element Eliminates Leakage

Claiming a new concept in oil seal design, Chicago Rawhide Mfg. Co., Chicago, Ill., has developed a shaft-type oil seal called Scotseal that avoids what has been recognized as major causes of leakage. The oil sealing lip is secured and completely enclosed so that it seals within the unit and does not contact the shaft. The sealing surface, normally a responsibility of the user, is provided by the seal. Use of the self-contained design precludes damage and leakage through improper handling before assembly, damage by assembler or shaft during installation or by improper shaft finish.

Scotseal consists of two parts which have relative motion to each other. The outer unit is an encasing shell with a portion of the inner surface serving as the surface against which the sealing member runs. The inner unit is the metal reinforced synthetic rubber sealing member, because the sealing element fabrication stays in place and lubricates the sealing lip through centrifugal action.

According to Chicago Rawhide, tests have shown that the unit seals without leakage and runs cooler with less friction and torque. Shafts need not be specially hardened, ground or polished over area where seal contacts the shaft.

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FORWARD WAVE AMPLIFIER

Crossed-Field Design Raises System Efficiency

While details of development of crossed-field forward wave amplifiers are classified, Litton's Electron Tube Division is now designing actual specific crossed-field tubes. The tubes are for pulse & CW applications at a variety of frequencies and power levels.

From experimental results and theoretical studies, Litton engineers found that the crossed-field forward wave amplifier provides many advantages over other types of existing and contemplated backward and forward wave amplifiers. In comparison with the O-type traveling wave amplifier, for example, the crossed-field forward wave device offers higher average CW power, higher efficiency, broader bandwidth, and smaller size and weight per unit of power output. The type of field orientation in the crossed-field amplifier allows the microwave propagating circuit to be wrapped into a circular configuration, resulting in very pronounced size and weight reductions as well as permitting family type design such as is found in magnetrons and backward wave oscillators. Use of the crossed-field amplifier, according to Litton, will greatly aid in raising overall system efficiency; use of a permanent magnet eliminates solenoid power requirements and heat generation.

The non-re-entrant beam forward wave crossed-field amplifier has few of the restrictions of crossed-wave backward wave amplifiers. Because of the absence of electronic or other inherent feedback mechanisms, it offers higher gain, broader bandwidth, greater power capability, and no noise or spurious oscillation in the absence of r-f drive.

TWO TYPES OF AMPLIFIERS

There are, generally speaking, two types of forward wave, crossed-field amplifiers. The first is an injected beam type and the second, a distributed emission type. The first type is basically a traveling wave tube except that the electron interaction is of the magnetron type rather than the klystron type as in conventional traveling wave tubes. The electron gun has a currentless beam control electrode, the accelerator, which is a convenient wattless amplitude modulation control; and it also has another currentless phase control electrode, the sole, which may be a very convenient electrical phase shift control.

The second type, employing the distributed emission type of forward wave, crossed-field interaction is basically a magnetron amplifier and is capable of high peak power outputs or extremely high CW power outputs—typically several orders of magnitude higher than that of magnetrons because the cathode and anode surface areas are much greater. Considerable thought has been given at Litton to the use and design of a distributed emission type of forward wave device which can operate as a linear Class B amplifier. In this mode the beam current could be turned on and off with the r-f signal. The initial major effort at Litton Industries has been concentrated on the injected beam type of tube.

In magnetron interaction used in this tube, the electrons are always phase focussed into the spatial phase of the r-f wave which is optimum for conversion of dc energy to r-f energy, regardless of the strength of the r-f field. The resulting electron bunches remain stable and in synchronism with the growing r-f wave throughout the interaction period. In these synchronous bunches, the electrons slowly work their way across from the sole to the slow wave structure, giving up to the r-f fields the energy acquired from moving across the dc potential lines. When conditions are such that all electrons forming any given bunch completely interact and are collected on the delay line, the tube is operating in the r-f saturated region. Collection on the slow wave structure itself is normal and takes place at the relatively slow synchronous velocity. Driving the tube beyond saturation merely shortens the length of the delay structure over which interaction takes place. Under no conditions of linear or saturated operation are the bunches put in a position to extract rather than contribute energy to the r-f wave. One effect of this is that the crossed-field amplifier can use a greater portion of the cold bandwidth of the slow wave structure than its O-type traveling wave tube counterpart.

COMPARISON OF CROSSED-FIELD AND O-TUBES

It is important to note that in the crossed-field amplifier, at saturation and beyond, there is no appreciable change in phase of the bunches relative to the space harmonic wave on the delay structure. Consequently, variation of r-f drive at saturation and beyond will have little effect on the

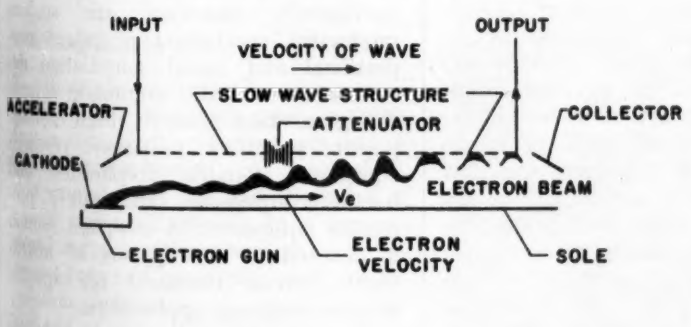

Fig. 1 Injected Beam, Crossed-Field Forward Wave Amplifier.

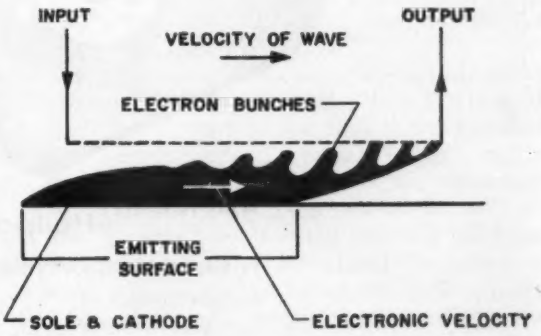

Fig. 2 Distributed Emission, Crossed-Field Forward Wave Amplifier.

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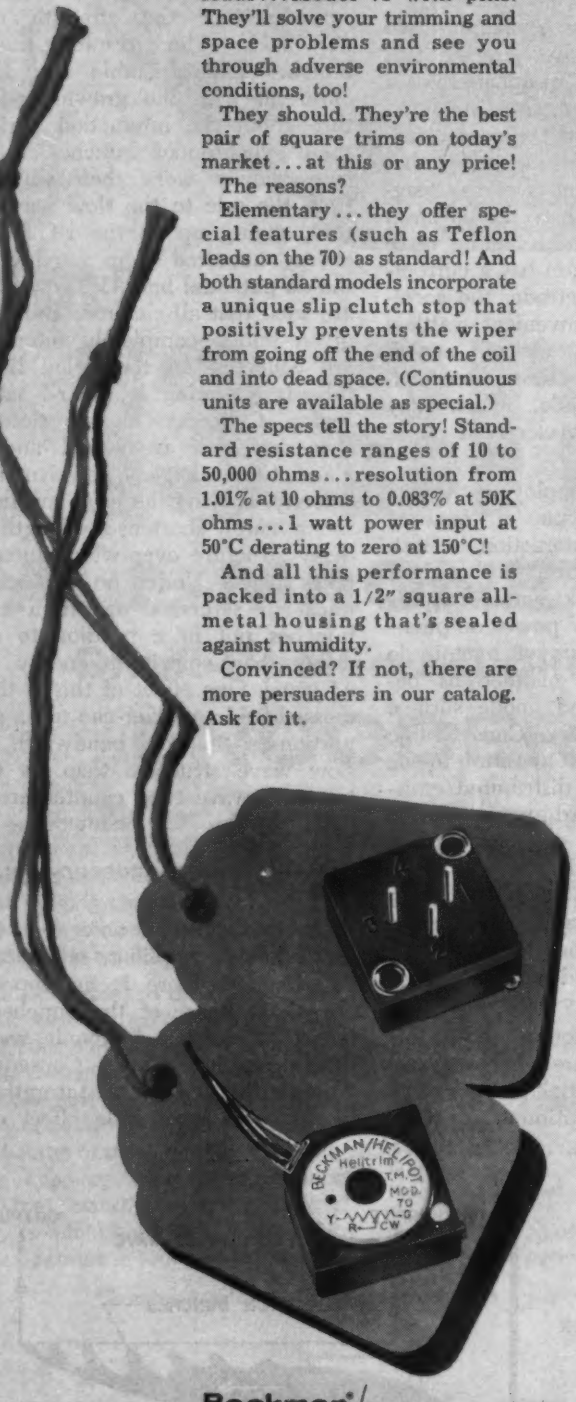

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total phase shift through the tube. Furthermore, as the crossed-field amplifier is driven to saturation and beyond there is no decrease in power output. As long as complete electron interaction takes place the electronic efficiency remains constant, independent of r-f level, line impedance or frequency.

By contrast, electron interaction in the O-type traveling wave tube depends on extraction of energy from the beam by changes in longitudinal velocity of the bunches, and consequently the phase of these bunches changes relative to the space harmonics. The magnitude of this phase change depends on the strength of the r-f wave. Overdriving the traveling wave tube causes the bunches to change phase so radically that they begin to take energy from the r-f wave, causing the power to fall off; the phase shift through the tube then becomes unstable. At saturation and beyond, electrons in the beam are in an unstable, overbunched condition, causing an increase in the harmonic content of the output. No comparable problem exists with the crossed-field amplifier.

Finally, because of the inherently high efficiency of magnetron type interaction, higher efficiency at high power outputs are more readily obtainable from the crossed-field amplifier than from the O-type traveling wave tube, at comparable frequencies and power levels.

Litton will make information and the tube available to properly qualified government contractors.

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WORTH FILING

Nuclear Instruments

64 page catalog of nuclear laboratory instruments and related accessories contains complete descriptive information and specifications. Among the instruments described are scalers, ratemeters, spectrometers, geiger, proportional and liquid scintillation detectors, manual and automatic sample changers, data printers, high voltage power supplies, radiation research equipment, sample preparation and handling equipment and safety protection equipment. A ten-page section is devoted to descriptions of instrument systems designed for specific sample counting applications.

Source: Tracerlab,
Waltham, Mass.

For Your Copy: Write No. 472 on Inquiry Card

MEASURING RANDOM SIGNALS

Voltmeter has long averaging time and high peak factor

Since properties of many electromechanical systems and electronic devices can be studied with greater efficiency with the use of random input signals, considerable attention has been directed towards the problem of analysis and measurement of these signals.

Engineers at Flow Corp., Arlington, Mass., involved in the design of a true rms voltmeter specifically for random signal work, defined two major problems in measuring random signals: (1) handling the peak values without overload or cutoff (2) averaging time must be as long as possible in order to obtain the correct sum of powers for frequencies fairly close to one another (e.g., in narrow-band spectrum analysis).

PEAK VALUES

Peak factor of a signal is defined as the ratio of the peak value of the signal to its rms value. Peak factor of a meter means the highest peak factor the meter can accept without overloading, the rms value of the signal being such as to make one expect the meter to read at full scale. (Of course, switching to another scale will allow the meter to avoid this overloading, but the reading will now be at the low, inaccurate, end of the scale).

The thermal readout device (described in Fig. 1) in Flow Corp.'s voltmeter provides for a full scale peak factor of ten. This means, for example, that rectangular pulses re-occurring at periods up to 100 times their duration can be read correctly, even at full scale position. (Fig. 2 illustrates that the distance the peaks can be separated and still have the meter read correctly at full scale, depends on the square of the peak factor.)

AVERAGING TIME

To illustrate the problem associated with a short averaging time, suppose that a signal, after filtering, consists of exactly two frequencies, one of 1 volt rms at 1004 cps and the other of 1 volt rms at 1006 cps. In a conventional meter, readings will oscillate between two and zero volts, with an oscillation frequency of two cps. The average of these two readings will be 1 volt, as compared to the correct rms value of 1.41 volts. This discrepancy is due to the quadratic calibration of meter faces. What is needed is an average of needle position, rather than a reading average. While mental time averages of needle position may be possible in the above illustrated case, the superposition of additional frequencies (always present even in sharply filtered signals) produces a needle movement of such complexity that the determination of the average rms value of the signal becomes exceedingly difficult.

The use of a long time averaging-circuit in Flow Corp.'s Model 12A1 voltmeter overcomes this difficulty, giving in the above example, a steady reading of 1.41 volts. To avoid any awkwardness associated with waiting for the long time averaging of 16 secs, a rapid response circuit is included in the unit. Merely throwing a switch gives an approximate reading so that the right range for the slow-response position may be chosen. Also, use of a special thermal bias circuit increases the rapidity of obtaining a reading in the slow-response position.

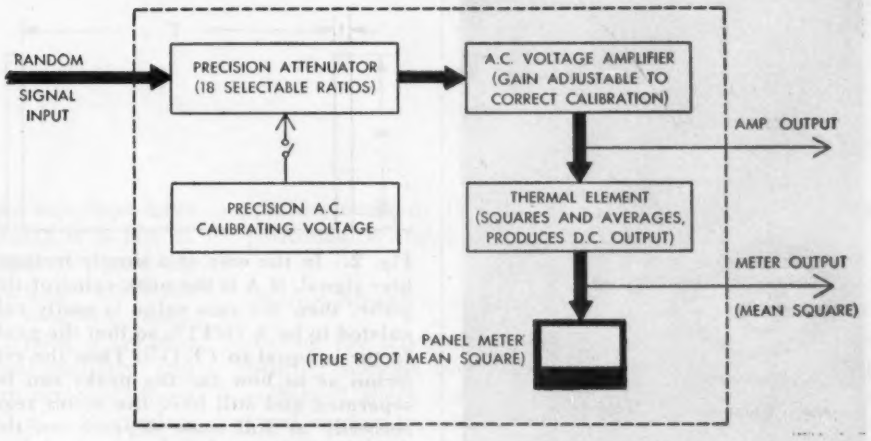
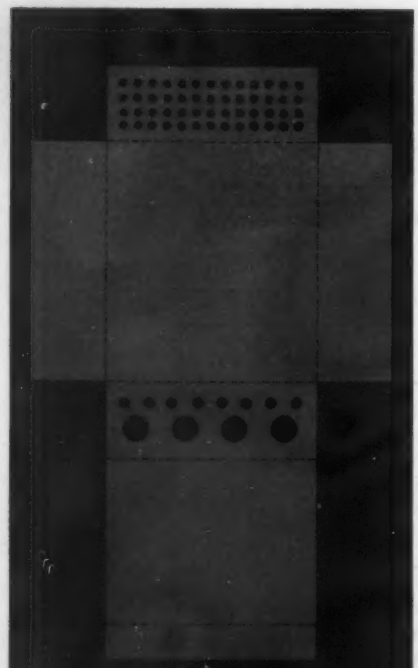


Fig. 1. Interval block diagram of Flow Corp.'s Model 12A1 random signal voltmeter. In order to permit high-peaked signals to be read correctly at full scale, the readout device employs forty-five thermocouples in series so that a temperature rise of 10 C is enough to give full-scale meter reading. Heating elements are of carefully chosen mass/conductivity ratio to give the long time constant of 16 sec. In tests, high-peak transients producing short duration temperatures as high as 200 C (measured at the heater core) have been read out without damage. Thus the peak factor is limited only by the maximum excursion of the output tube and overload protection is automatic. The readout elements have been used directly at frequencies from dc to several megacycles without error; the frequency range is limited only by the associated amplifier. No transformers are used since the readout device has an input impedance of ten K and an output impedance of 100 ohms. Since the long time constant is achieved in the readout device, the averaging characteristic of the indicated panel meter attached to its output in no way affects the measurement. The internal signal is generated through Zener diode clipping, providing an extremely stable reference signal independent of line voltage and ambient temperature. Power supply includes a line voltage regulator, and amplifier circuits are feedback stabilized so that calibration adjustments will rarely be required.

REVIEW OF AC MEASURING DEVICES

Engineers at Flow Corp. summarized the several types of true rms meters available as follows:

- A dynamometer is an instrument similar in construction to a D'Arsonval instrument except that the permanent magnetic field is replaced with a coil of wire. The deflection of the pointer is proportional to the product of two currents. The damping serves to integrate the torque variations and the deflection can be made proportional to the square of the rms voltage applied. These instruments can be made with high accuracies but have limited frequency response.



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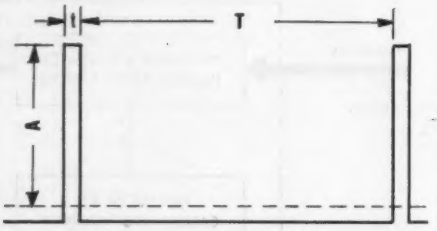

Fig. 2. In the case of a simple rectangular signal, if A is the peak value of the pulse, then the rms value is easily calculated to be A $(t/T)^{1/2}$, so that the peak factor is equal to $(T/t)^{1/2}$. Thus the criterion as to how far the peaks can be separated and still have the meter read correctly at full scale depends on the square of the peak factor rather than on the peak factor itself. A true rms meter with a peak factor of three, reads correctly, at full scale, up to $T/t = 9$; Flow Corp.'s model 12A1 will continue to read correctly up to $T/t = 100$.

● Iron vane instruments also respond to the rms value of the waveform but can seldom be used for anything other than power frequencies.

● Electrostatic voltmeters can be made to indicate the true rms value of the waveform applied. They have the advantage of high impedance at low frequency. Their disadvantage is their limited sensitivity.

● Electronic rms meters are based on a parabolic-transfer characteristic

$$e_{out} = ke_{in}^2$$

The average output voltage can be read on a dc meter and is the square of the rms value. Unfortunately the parabolic transfer characteristic is difficult to achieve accurately over a wide dynamic range. In some cases it is approximated with straight line segments, but a large number of segments is required if the error is to be kept small and a high peak factor is to be provided.

● RMS voltmeters have been constructed using various analog computing techniques for multiplying two variables. In this case

$$e_{out} = e^1 e^2$$

The voltage to be measured is fed in as both variables and the average of the output is the square of the rms value. These techniques offer great flexibility but the instruments are very expensive.

● Thermocouple instruments, based on the measurement of thermal energy, respond to dc up to tens of megacycles. For example, vacuum thermocouples have long been used for rf measurements, but unfortunately they are easily susceptible to damage due to overloading unless the peak factor is severely limited.

● Flow Corp.'s signal voltmeter uses an electronic thermopile (45 copper constantan thermocouples bonded to a resistance element) that combines the advantages of the broad frequency response of a thermocouple instrument with the high sensitivity of a vacuum tube preamplifier. The voltage to be measured is amplified and applied to a highly stable resistance material which is bonded to silica and surrounded by an inert atmosphere. The resistor converts the voltage into thermal energy which is then measured by the electronic thermopile and read on a precisely-calibrated D'Arsonval meter.

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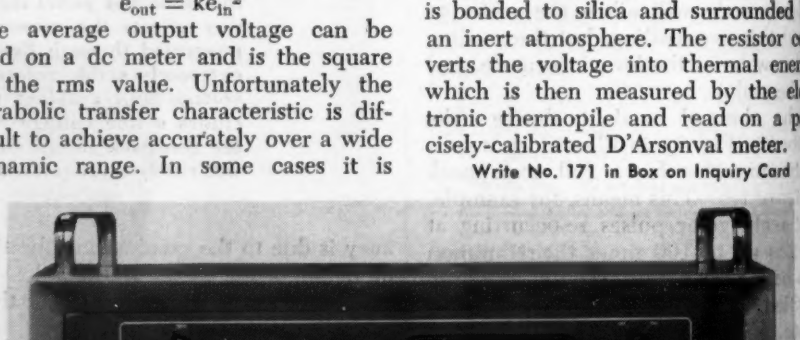

Fig. 3. Although Model 12A1 was designed for random signals, its reliable readout and high-peak factor are useful also in the measurement of low-frequency and highly-peaked periodic waveforms, such as those encountered in non-linear servo-mechanisms and programming systems, sub-harmonic ferro-resonant problems which arise in magnetic amplifiers, mechanical vibration systems or shakers and recurrent pulse loading devices. The voltmeter contains an extra scale calibrated for direct correlation measurements (—1 to +1, zero to center). An accessory unit, Model 13A1 Random Signal Correlator, is available for measuring the correlation number directly.

WATT-HOUR METERS

Magnetic Thrust Bearing
Key to Friction-Free Design

Magnetic bearing systems of an entirely new type have replaced conventional ball-and-jewel bearings in a line of single-phase 120/240-volt watt-hour meters designed by Westinghouse Electric Corp. In these meters, disk-and-shaft assemblies are supported in space by the magnetic repulsion between two tiny rings of barium ferrite, a ceramic permanent-magnet material of exceptional stability and strength. Mounted so that their fields are opposed, these rings serve as the two "working surfaces" of a frictionless thrust bearing. Supplying the slight lateral forces needed to restrict horizontal movement are stationary pins within graphite journals which serve as guide bearings for the upper and lower ends of the shaft.

In describing the development, T. D. Barnes, engineering manager for the meter department, said that the new Magnethrust bearing design would be used in all single-phase meters produced by Westinghouse after June 1, 1960. He also indicated the new D2S meters would be priced competitively with existing designs and would also display new improvements in the light load adjustment, dual-voltage performance, stability, and corrosion resistance.

DESIGN ADVANTAGES

Among the advantages cited by Mr. Barnes for the new bearing systems over existing designs were the ability to withstand shock and vibration well above levels encountered during transit, immunity to thermal shock and environmental change, tolerance to off-vertical installation, and, particularly, its ability to serve for "at least 30 years" without maintenance.

Playing a major role in the new design are the unique properties of barium ferrite, a ceramic magnetic material produced by sintering barium carbonate and iron oxide. It is the only known material that displays its full magnetic stability at its greatest magnetic strength; it thus does not require any back-off of magnetization to achieve maximum magnetic stability. A second important property is that it is

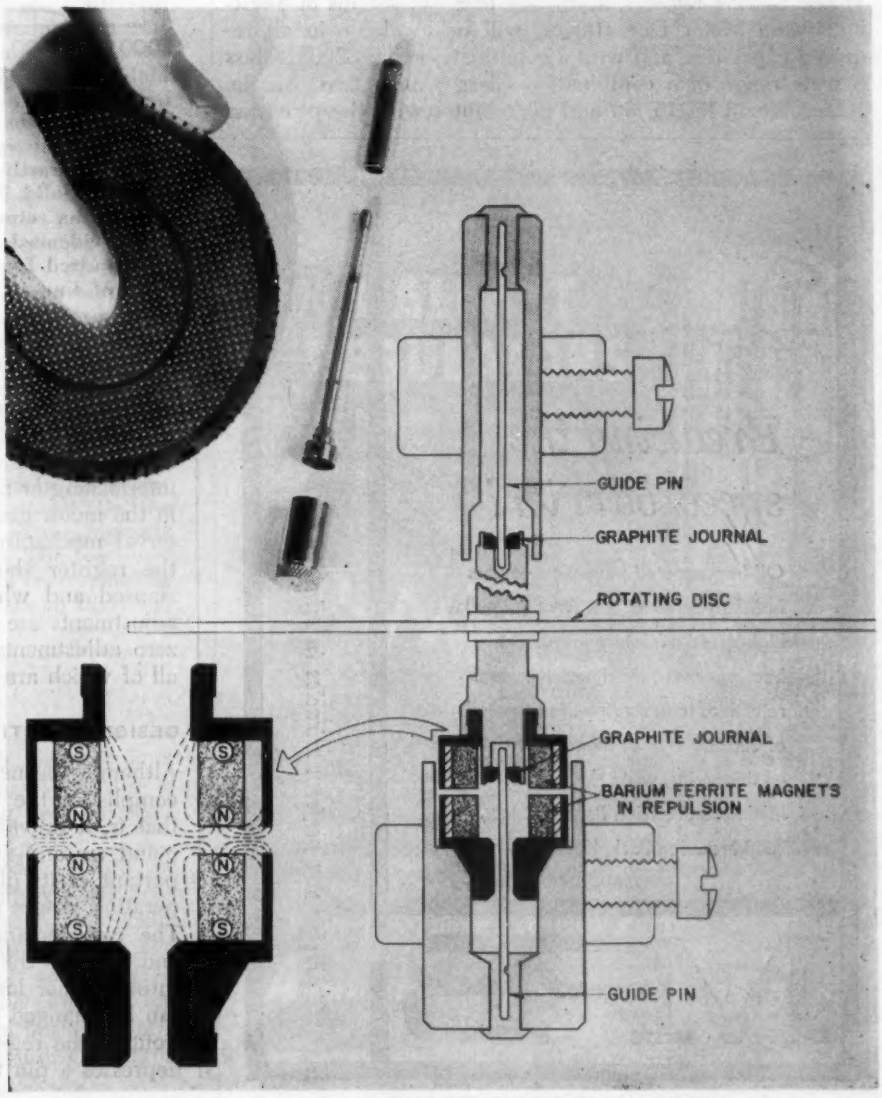

Fig. 1 In the Magnethrust bearing system, two rings of barium ferrite are die-cast mounted in steel flux-return cups that are precisely machined to close tolerances of concentricity. When assembled as a working bearing, with the rings in repulsion and one-fiftieth of an inch apart, this limited air gap and low flux leakage combine to contribute high magnetic efficiency, vertical "stiffness," and virtually no susceptibility to external magnetic fields. Independence from external fields can be verified by noting the absence of magnetic attraction on iron held adjacent to the bearing system. At the upper and lower ends of the rotating system, the guide bearings that restrain side thrust on the shaft combine polished and hardened chrome steel pins and journals of nearly pure graphite. Both upper and lower pin-and-journal pairs are loaded very conservatively. Pressures are only three grams at the top bearing and less than seven grams at the bottom bearing at maximum meter load. Life tests conducted at maximum torque under a variety of test cycles have produced no discernible wear after 100,000,000 shaft revolutions.

nearly impossible to cause any appreciable decrease in magnetic strength of barium ferrite except in a well-equipped laboratory. This property is particularly desirable in watt-hour meters since it contributes a high degree of immunity to tampering or damage by current surges. In addition to its purely magnetic properties, barium ferrite also is well-suited for use in watt-hour meters because of its chemical inertness, its imperviousness to temperature extremes, its low density, and its high electrical resistivity.

DUAL RANGE DEMAND REGISTER

At the same time it announced the new bearing design of their watt-hour meter, Westinghouse also stated that their new Mark I demand registers permit conversion of watt-hour meters to watt-hour demand meters. This equipment is identical to watt-hour meters except for the addition of the demand register and its necessary components: two lead connections for the motor and a large glass cover with a mechanical reset. The mechanical demand register gives a combination of the kilowatt-hour consumption, just as does the standard kilowatt-hour register, and in addition, gives the maximum kilowatt demand over a definite time interval by means of a pointer moved over a graduated demand **scale.**

The Mark I register, according to R. V. Adams of Westinghouse's Meter Department, will be available in all required capacities, and with a combination Class 2 and Class 6 scale range or a combination Class 3 and Class 5 scale. Intervals will be 15, 30 and 60 minutes with the provision

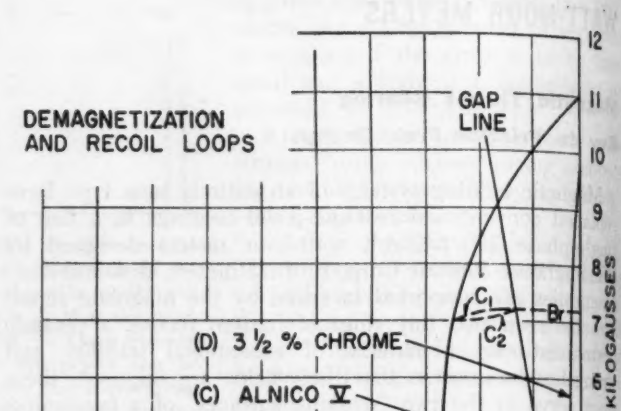

Fig. 2 Barium ferrite has no minor hysteresis loop, as the residual induction (B_r) is constant after being demagnetized temporarily by force equal to its inherent H_c of 1800 oersteds. Solid line is original induction curve; dotted line that of flux return after demagnetization. Exceptional stability is evidenced by fact that fields of 20,000 amp turns/in are required for magnetization. Other materials such as alnicos of Curve C, require an initial normalizing to provide minor hysteresis loops (C_1 and C_2) for full reversibility.

that up to 4 hours intervals can be made. The Mark I easily mounts on all "D" line watt-hour meters without extra transfer gearing or meter recalibration. It is available with 4 or 5 interlocking or noninterlocking kilowatt-hour dials. A clutch in the motor gear train allows advancement of the time interval mechanism by hand. An indicator on the front of the register shows how much of the time interval has elapsed and when the interval is completed. Only three adjustments are necessary for calibrating the register: two zero adjustments and a black pointer friction adjustment, all of which are on the front of the register.

DESIGN FUNCTION

Although the new Mark I mechanical demand register accomplishes the normal functions of a demand register—that is, it provides both a kilowatt-hour reading and a demand reading—it does it in a unique way. The most important of its distinctions is that the register has two operating ranges and is hence actually two registers in one. The two demand ranges allow installation for high loads and also has the ability to be changed in the field to meet future higher loads. In this equipment, the demand range can be changed simply by reversing the scale plate on the front of the register. In so doing, a tab on the scale plate depresses a pin that performs a simple gear change which

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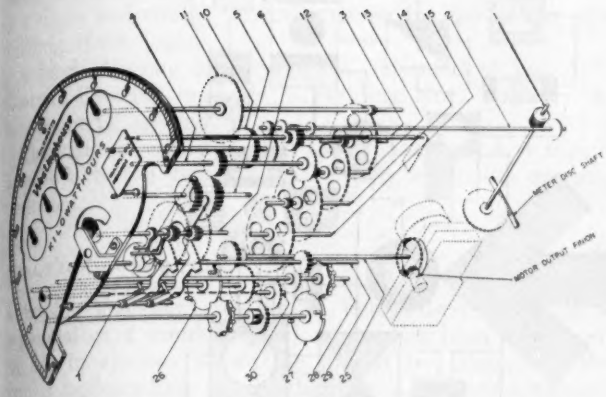

Fig. 3 The meter disc shaft drives the worm wheel on shaft (1). Shaft (1) turns shaft (2) which turns shaft (10) the kilowatt-hour gear train and the pointer shafts (11) (12) (13) (14) and (15). Shaft (2) also turns shaft (3) which is the dual range shaft. Both shafts (2) and (3) have two gears and pinions which change mesh when the scale plate is reversed to change the range. As an example of these steps, to change from one range to another range, the scale is reversed. The tab seen at the left (near the 0.1 graduation) depresses shaft (3) which is then put under spring tension. This action disengages a gear and mating pinion on shafts (2) and (3) and automatically engages a different gear and pinion on these two shafts. This change in ratios automatically corresponds with the graduations of the scale desired, due to the contour of the scale plate. The dual range shaft (3) turns shaft (4) which turns the demand clutches on shaft (5) alternately depending on which clutch is engaged. Each clutch on shaft (5) turns its mating gear on shaft (6) when its clutch is engaged. Shaft (6) also has two pushers which work with the two corresponding clutches and push the demand pointer upscale to indicate the demand. The time interval is established by the operation of a synchronous motor as it drives through a gear train to a cam which trips the clutches and returns the pushers to zero by its action on two sector gears. Operations are as follows: Crown gear shaft (25) is turned by the output shaft of the synchronous motor. Shaft (25) turns shaft (26) and the driving disc on this shaft turns shaft (27) which turns the time elapsed indicator shaft (30) and also has a driving disc which turns shaft (28). Shaft (28) drives the cam shaft (29). The cam on shaft (29) performs a dual function: A. It pivots a lever arm which rides in the center of the cam and engages a clutch for the interval. On the next interval the cam pivots the lever arm in the opposite direction and engages the opposite clutch. B. The top outer surface of the cam depresses a spring on the corresponding sector gear on shaft (7) and drives the pushers on shaft (6) to zero. The cam action always returns the disengaged pusher to zero before the end of the interval and keeps the clutch open time to less than 1 second.

in turn doubles the range of the demand portion of the register. However, this does not affect the kilowatt-hour gearing or reading. By designing the demand register to change scale tab gears, positive interlocking between scale reading and gearing is provided.

A second feature is that the time required to return the pusher pointer to zero at the end of each interval has been reduced from typical values of 6 to 7 seconds to practically zero. To do this, two pusher pointers are used alternately. Change-over from one pusher to the other is accomplished by snapping an armature from one magnetic clutch to another at the end of each interval. The unused pusher pointer is returned to zero by cam action from the motor gear train.

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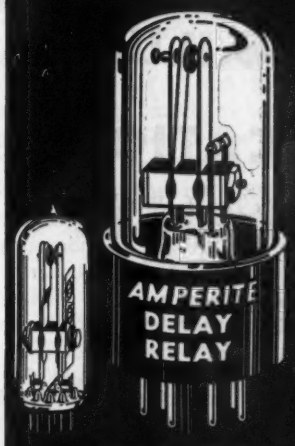

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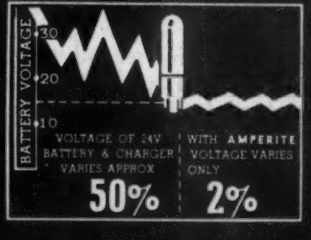

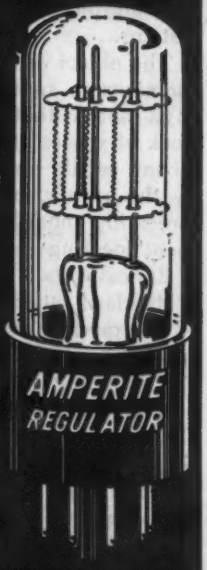

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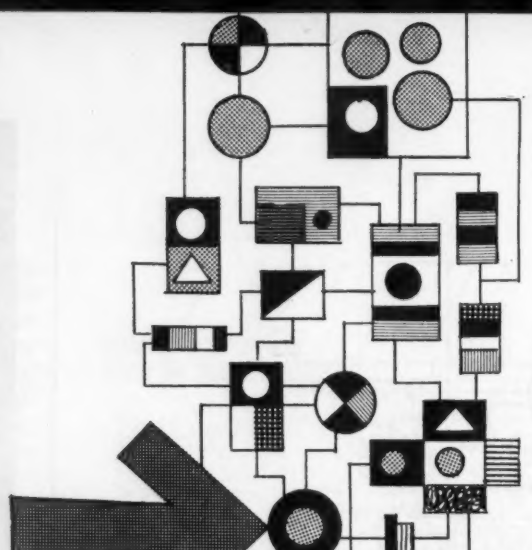

AUTOMATIC FAILURE LOCATION

*By D. H. Breslow,**
Raytheon Co., Wayland, Mass.

A Building Block Approach to Reliable System Maintenance

Restoring operation of complex military and industrial systems rapidly in the event of malfunction requires some form of automatic fault location, especially where repairs have to be made by relatively unskilled personnel.

Using a building block approach to this problem in the battery control center of a missile system, Raytheon has developed high-performance automatic fault location equipment with minimum complexity. The flexibility of the building block technique makes it applicable to many other systems.

The object of the fault location system is to localize malfunctions to specific replaceable assemblies. Many authors have noted that modular construction with a sufficient stock of spares at the point of use offers a method of minimizing repair time. Previous papers by W. B. Bishop and by the author, have demonstrated that the use of failure-indicating modules (FIM) can greatly minimize the time spent locating the defective module.

Basically, two things must be done to test a module: 1) A standard set of inputs must be supplied. 2) The outputs of the module must be checked with the standard inputs applied.

A building block solution to the second of these two problems has been thoroughly discussed by the author. (See *Failure Indicating Modules*, Electromechanical Design, Dec. 1959, pg. 18). Basis of this solution is a new waveform sampling device called a comparator network that converts ordinary modules into failure indicating modules (FIM). Each module contains sufficient comparator networks to represent its performance by a single dc test voltage on a go/no-go basis. These failure indicating modules in turn are building blocks for systems. The comparator network is truly a building block. It can be designed with parameters such that it is universal for an entire system. Its flexibility is further insured by the fact that all reference voltages for the compared signal are generated external to the comparator.

The article cited above, being concerned only with the second problem—applying the comparator to checking a module's output signals, assumed that all inputs were somehow known to be good. This article, attacking the first of the two problems, will show how building block logic may be applied to using FIM's as sources of test signals for other FIMs.

In a complex system, two principal methods for inserting test signals can be used—parallel or series programming. Parallel programming means adding (logically) signals to existing lines without breaking the original lines. An example of the parallel type is adding simulated video through a mixing diode to a radar output. Series programming involves adding information by substitution of the system variable. An example of the series type is the switching in of 3 wire synchro information via a set of relay contacts. Both types of programming involve adding extra paths to the system. This series type may lead to degradation of reliability if carried to excess.

In most systems, some amount of each type of programming can be expected. However, it should be kept to an absolute minimum for reasons of reliability and economy.

Examination of the block diagram of most systems reveals that the outputs of most modules eventually become the inputs of other modules. Hence, in a properly chosen test sequence, the outputs of modules known to be good can be regarded as a set of standard input signals for succeeding modules in the system.

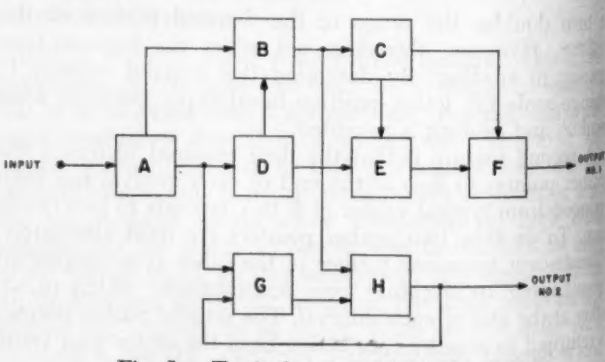

Fig. 1. Typical system block diagram.

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Recall that each module to be tested is of the FIM type. The problem of failure location then resolves into answering the following question: Does a module in an apparent failure state need replacement, or does it show failure because of trouble elsewhere. This question can be answered in a single and straightforward manner by application of a building block logic.

A block diagram of a system is presented in Fig. 1 to illustrate how the methods of building block failure location might be applied.

The logic necessary to scan the input-output test signals may be either of two principal types: sequential or combinational.

ANALYZER OPERATION

A flexible analyzer, capable of being used as either a sequential or a combinational tester, has been developed for use in systems where the output test signals of the various modules have been reduced to a single test voltage. A photograph of this device is shown in Fig. 2. Fig. 3 is a simplified schematic diagram showing the logic of the device. The operation is as follows:

When a malfunction occurs, the tester, which consists of a rotary stepping relay and suitable control circuits, is started by applying a signal called START. The test set always starts from its home position; before it can leave its home position it must pass a series of self tests. The actual starting signal may be obtained from a push button switch, or in some cases, it may start automatically. In the home position, the cam-operated off-normal switch of the stepping relay is in the position shown. The start signal, which is the nominal level of a test signal in the failure state, is applied through the off-normal switch to both the SKIP and STOP relay circuits. The step relay coil circuit is energized through series connected contacts on the SKIP and STOP relays. Both SKIP and STOP must be operated to start the test sequence. If either is faulty, the analyzer designates itself as a failure. When the analyzer is acceptable, energizing the coil of the stop switch causes it to advance one step, releasing the cam-operated off-normal switch. The series connected contacts on SKIP and STOP then loose control of the step relay coil. The start signal applied simultaneously to the SKIP and STOP relays is also removed when the off-normal drops out.

Once the test set has passed its own self-tests the operation may be readily understood through an explanation of the STOP and SKIP circuits. Note that when the step relay leaves home, the STOP relay is connected so that when it is operated the stepping relay coil is de-energized, halting the step relay. The bank of the step relay that controls the STOP relay is wired with the test signals of the modules that are scanned, so that the STOP circuit tends to stop the test sequence whenever a bad test signal is located. However, the SKIP circuit is wired so that a normally open contact on the SKIP relay is in parallel with a normally closed contact on the STOP relay in the step relay drive circuit. If SKIP is energized, the step relay coil will be energized regardless of the state of STOP, causing the test sequence. To the positions of the SKIP banks are applied the test signals of the modules driving the module whose test signals are applied to the STOP banks.

The STOP bank of our test set in Fig. 3 is wired as it would be for the hypothetical system of Fig. 1. If only serial logic were desired, then this bank would be the only requirement of the test set to locate the defective modules. If combinational logic is desired, then the SKIP banks and the SKIP circuit must be added. The purpose of the SKIP bank is to cause the test sequence to continue until a module is located which has an acceptable set of input signals and a faulty set of output signals. The presence of the SKIP circuit makes the logic of the test sequence combinational, since there is always information present concerning the state of the driving modules. The number of SKIP banks needed is equal to the number of inputs of the module with the greatest number of inputs. In our example, two SKIP banks are sufficient since no module has inputs from more than two other modules. When combinational circuitry is used, the order of testing is arbitrary.

The combinational logic is not acceptable when feedback

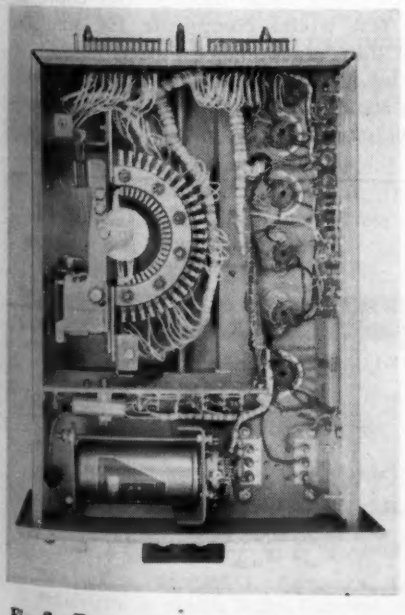

Fig. 2 Representative test set module.

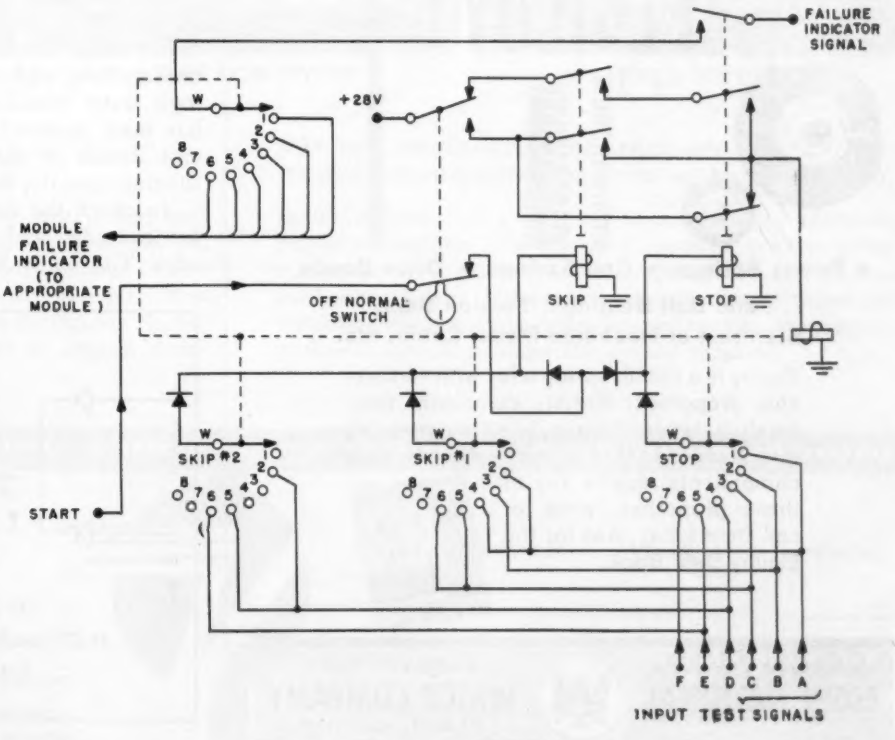

Fig. 3 Test set simplified diagram.

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paths, such as the one between modules G and H in Fig. 1 are present. In this case, the test set would be unable to designate either module as a failure, since, if there is a failure in the loop, both modules will show apparent failure and both are capable of inhibiting each other. There are three possible solutions to this problem:

- If the feedback path is one of location of circuits rather than one of a true feedback loop, then relocating the circuits to obtain a series connected logic flow will solve this problem.
- If the circuits cannot be relocated, the various test signals may be expanded so that a test signal will not include a whole module, but rather only a portion needed to establish a straight line flow.
- If the feedback path is a true feedback path, then there are two options: a) Open the feedback loop with suitable programming and locate each module on an open loop response basis. b) Check the modules on a closed loop basis and make any failure indications and ensuing repairs on a matched pair basis.

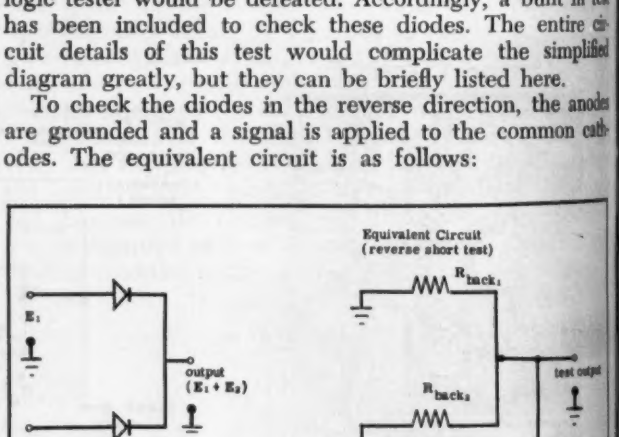
The SKIP banks are wired for the example of Fig. 1. The wiring for modules G and H is not shown since this wiring will be a function of how the feedback path is handled.

SELF TEST OF ANALYZER

Self test features of the test set are very important. The test set is the link that sifts the failure symptoms and energizes the failure indicator. Since complexity of the test set approaches that of a typical module, a self failure indication is needed for system continuity. The test set described has a fairly simple logic which is easily checked by switching over from parallel to series operation and insuring that all relays are capable of operation with a nominal failure test signal.

The two diodes whose anodes are connected to the wires of the SKIP banks form a very important OR circuit. If either diode should open or short, the SKIP circuit would malfunction, and the whole purpose of the combination logic tester would be defeated. Accordingly, a built in test has been included to check these diodes. The entire circuit details of this test would complicate the simplified diagram greatly, but they can be briefly listed here.

To check the diodes in the reverse direction, the anodes are grounded and a signal is applied to the common cathodes. The equivalent circuit is as follows:



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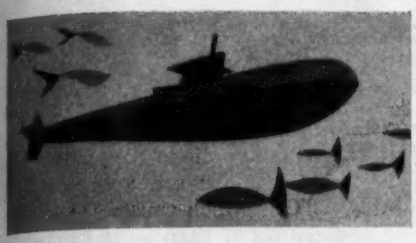

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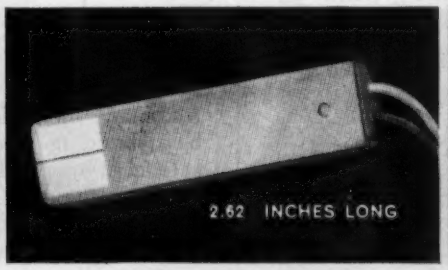

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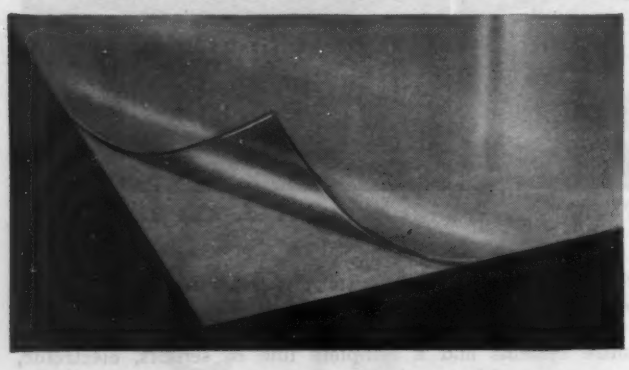

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Opens are checked by programming extra positions of the test set with simulated SKIP signals and using these to cancel an internal STOP command. Reverse leakage could be checked on an individual basis, but there are not always sufficient extra positions. Hence, the group reverse test is advantageous in that stepping relay capacity is not unduly consumed on internal tests.

Other functions performed by the analyzer are to program command signals, and where required, substitute test signals where the equipment cannot supply its own. Also required are signals to indicate which portions are being tested, means for cascading test sets, and means for resetting the tests should it be desirable to restore normal circuit operation from the test mode. By providing a SKIP circuit and combinational logic, the flexibility of the test set is greatly increased with little engineering effort. This is because STOP and SKIP are identical circuits up to the wiring of certain relay contacts. It is possible, by proper design of the test set, to place it on the same modular building block basis as the comparator such that the same unit can be used to test a wide variety of types of circuits and logical configurations.

BUILDING BLOCK APPLICATION

Automatic fault location systems composed of the two basic building blocks (comparator and test set) are characterized by rapid fault location ability with a minimum of test equipment and a minimum of engineering design time, once the blocks have been designed.

Engineering time needed to design the necessary test equipment can be minimized when off-the-shelf logic elements are available. The comparator is flexible enough so that it can be applied as a basic component. Although no curves are available, all that is required is a simple set of curves showing the reference voltage needed to show a desired failure level for a few typical waveshapes. Once these curves are obtained, the application of the comparator is considerably simplified. The test set developed for the Raytheon Battery Control Center is somewhat specialized but the logic needed to locate the defective module is applicable as a basic building block to other systems.

The design philosophy which led to the development of the basic building blocks was to provide a simple and reliable system of rapid fault location capable of detecting a minimum of 90 percent of those faults that would seriously impair system operation. Analysis showed that an attempt to indicate over 95% of failures would greatly increase the complexity of the test equipment. The building block test equipment with a capability of locating a minimum of 90% of all faults is less than 10% of the equipment complexity. Moreover, the test equipment is concentrated in the common synchronizer portion of the equipment so that this key section has considerably higher than 90% fault location ability.

The comparator is a complete logical package which is

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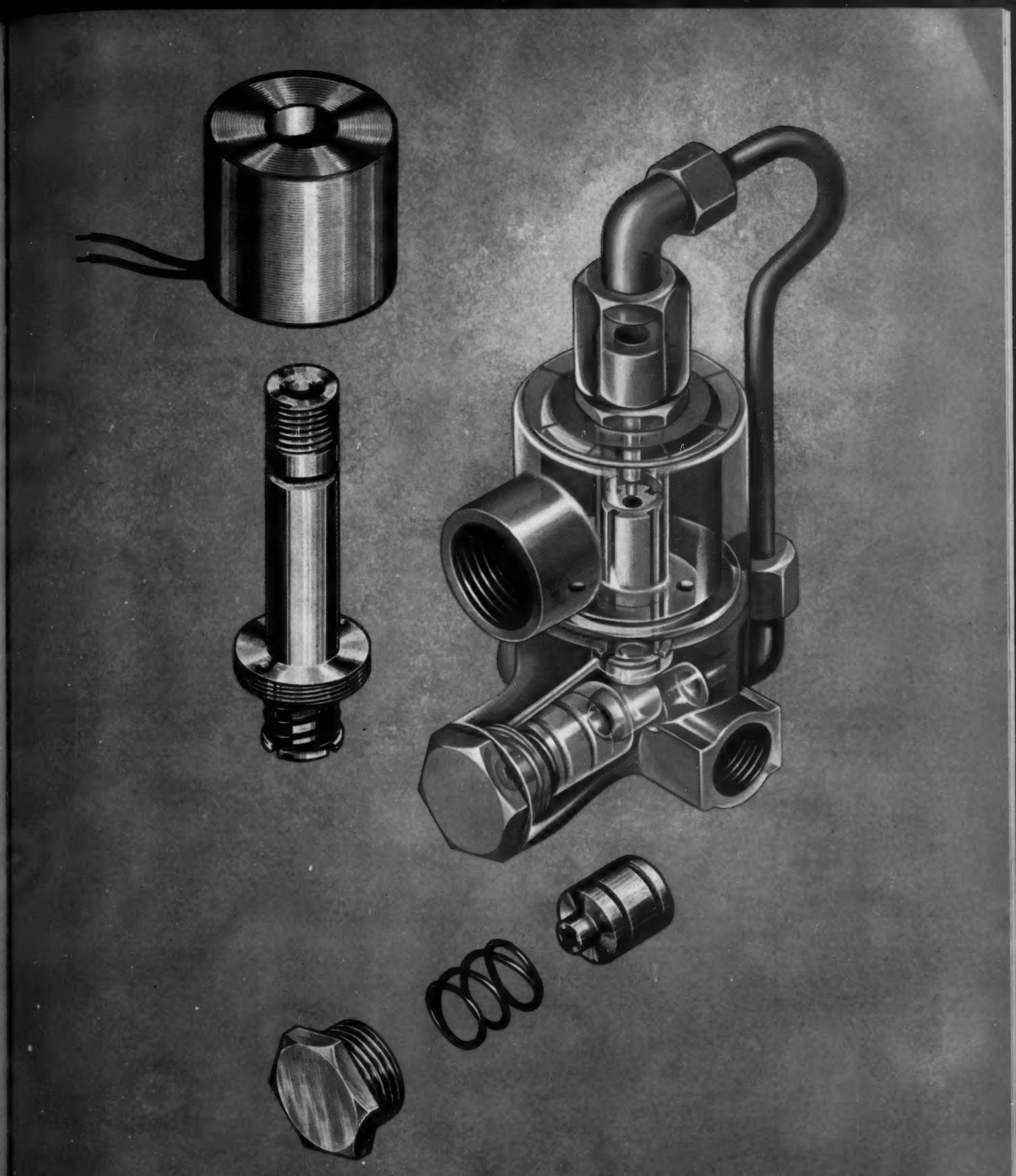

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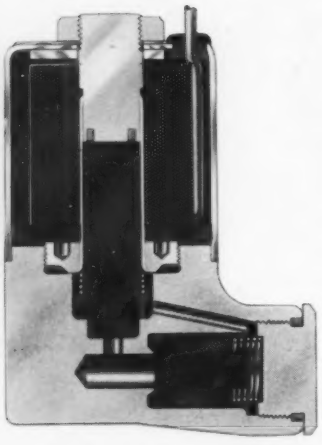
B—Coil C—Sleeve, plunger and spring assembly
D—Piston assembly with soft synthetic insert



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Cv Factor	.758	.758	.758	.758
Operating Pressure Differential (PSI) Minimum	5	5	5	5
Maximum AC Service	200	1250	—	150
Maximum DC Service	200	500	1000	150
Leakage	Bubbletight	Bubbletight	Bubbletight	Bubbletight
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THE SKINNER CHUCK COMPANY • NEW BRITAIN, CONNECTICUT, U.S.A.

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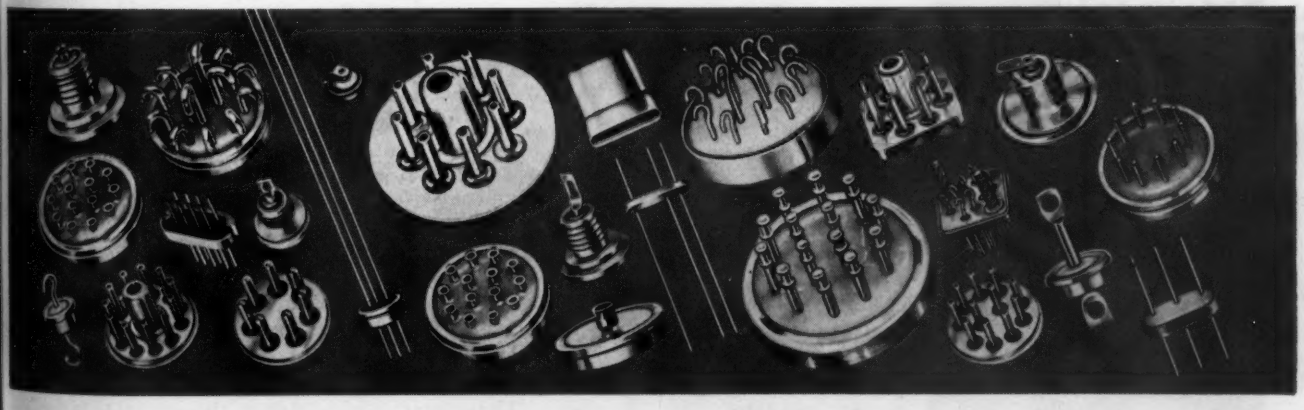
Versatile in Design — Dependable in Performance!

Specify the seals employed by leading manufacturers for complete reliability in vital space age programs and critical commercial equipment. E-I hermetically sealed terminations and custom sealed components have proven their ability to withstand the extreme environments encountered in today's most critical applications. In addition to their demonstrated dependability in all types of commercial and military service, E-I offers engineers widest possible design flexibility ... a complete line of standard seals, design service on "specials"... and custom sealing of assemblies of your own manufacture.



Write for Complete Information — on standard seals, special types or custom sealing service including miniature closures and color-coded terminals ... or ask E-I engineers for recommendations on your specific sealing requirements.

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MURRAY HILL, NEW JERSEY, U.S.A.
A Division of Philips Electronics & Pharmaceutical Industries Corp.

CIRCLE NO. 28 ON INQUIRY CARD

What is LOW COST?

Your initial purchase price is only a fraction of the true cost of your components.

We can reduce your cost, because ELECTRO-MEC precision potentiometers and digitometers are delivered

- on time
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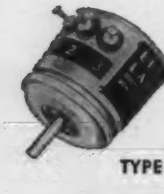
Therefore you

- save on receiving inspection cost
- enjoy assured performance after installation
- incur no production schedule delays.

You can rely on the experience and workmanship of ELECTRO-MEC



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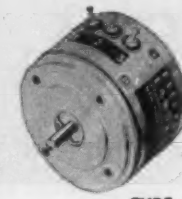

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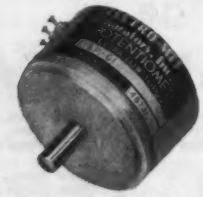

TYPE 18

TYPE 30

RELIABILITY = LOW COST

Only a few of our instruments are shown here.

Write or phone our engineering department.

ELECTRO-MEC LABORATORY, INC.
47-51 33 Street, Long Island City 1, New York
STillwell 6-3402

CIRCLE NO. 29 ON INQUIRY CARD

actually an elementary analog to digital converter. The device is flexible in application, and accommodates design changes by the simple expedient of changing a reference voltage. Danger of test equipment obsolescence is thus minimized. The comparator is basically a very reliable device. This reliability stems from many sources. The device is simple, consisting of passive components. The components are of the highest quality available and are very conservatively derated. Components that do not fail safe are paralleled for greater reliability. An interlock is provided so that in some cases removal of the comparator from its socket will be cause for a failure reading. The device has the capability of indicating that a signal has degraded to a certain level and can thus indicate when an assembly should be removed for preventive maintenance.

Capability of the test system to supply its own test signals has several advantages. Test equipment complexity is minimized and all operating circuits are checked under dynamic operating conditions. The actual loads and circuit configurations into which the system must work are connected. Switching and data handling circuitry and systems, characterized by a small amount of input data but with complex operations performed on this data, are advantageously handled.

Advantages of an automatic fault location system synthesized by the building block approach are

- Reliability
- Flexibility
- All readings are of the go/no-go type
- Test equipment is a small fraction of total system size
- Test equipment is self testing
- Engineering design time is minimized
- System is capable of being maintained with relatively unskilled personnel
- Marginal and degradation tests are possible
- Most tests are made under actual operating conditions

Transistor Thermal Test Set

A special nomograph included in a transistor thermal test set permits rapid determination of the transistor and diode junction temperature. Temperatures are read directly on a meter scale from accessories which include small thermoelectric junctions, a thermometer probe and evacuated glass enclosed thermocouples. Ambient temperature compensation is automatic. No batteries or other external power is required. Rescon Electronics Corp., Waltham, Mass.

Write No. 603 on Box on Inquiry Card

High-G Rotary Accelerator

Compact centrifuge tests subminiature electronic and electromechanical components up to 20,000 Gs of acceleration. Designed especially for testing transistors, relays and components up to four ounces in weight and one cubic inch in volume, the High-G rotary Accelerator consists of a welded steel test stand and an aluminum rotating arm. Incorporation of an air motor achieves vibrationless power output. The motor, which drives the spindle, is operated by the expansion and velocity of compressed air and requires 30 cubic feet per minute at 90 pounds per square inch. Unit exhibits a speed variation of less than 1%, speed resolution of better than 0.1% and full speed from standstill in less than 20 seconds. Rotation of the eight inch arm can be measured at low speeds to an accuracy of ± one count per ten second interval. Schaevitz Engineering, Pennsauken, N.J.

Write No. 512 in Box on Inquiry Card

FUEL-CELL

Smog Free Power for Cars

Exide Industrial Division of The Electric Storage Battery Company, Philadelphia, has signed agreements with 12 of the nation's material handling equipment manufacturers to jointly develop an adaptation of the Exide fuel cell to power electric industrial trucks.

Exide states it has overcome some major obstacles in converting fuels directly and continuously to high sustained electric currents at nearly normal temperatures and atmospheric pressures in a family of long-life fuel cells. Eventually, they state, their development could lead to the conversion from gasoline engines to smog-free, nearly silent electric power for automobiles and street trucks as large as conventional vehicles with speeds and driving ranges adequate for modern-day needs.

RECHARGEABLE ZINC OXYGEN UNIT

Already beyond the basic and applied research stages in the development of at least one type of fuel cell—a rechargeable zinc-oxygen unit that is the forerunner of other cells—Exide believes that within a few years it can develop practical cells, capable of being mass produced, that will be several times more powerful per cubic foot than any fuel cells so far demonstrated.

By using zinc as the fuel—compressed oxygen as the oxidizer—Exide has produced a cell of "great simplicity" and of "unusual" design that is strikingly different from most previously announced models which use gaseous fuels:

- operation at nearly normal temperatures and pressures
- no waste products to be removed
- ability to be scaled up or down in size and electrical capacity for a wide range of power requirements.

The agreements with the materials handling equipment manufacturers—virtually the entire industry—means that the mettle of Exide's fuel cells will be tested thoroughly in rugged, long-shift lifting and hauling operations.

Besides having greater power potential than other fuel cells now under consideration for early application, Exide claims its zinc-oxygen cell also has the advantages of having virtually no theoretical limitation on its physi-

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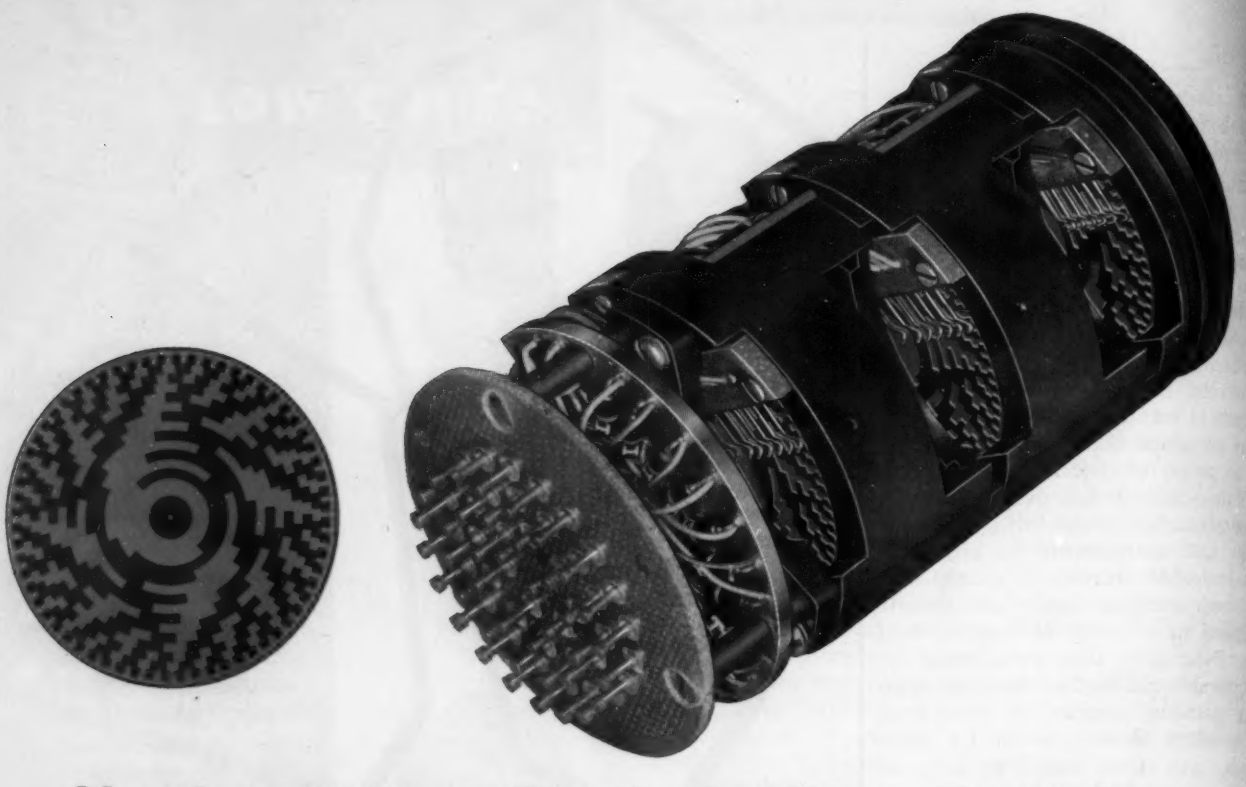


Norden V-Disc Shaft Position Encoder

—is the smallest size of its type to meet MIL specs

—gives 25% longer life than conventional V-brush type . . . at higher speeds

This Norden V-disc design, transferring V-brush logic to the code disc, permits precise single-line brush positioning. Radial displacement of the brushes reduces wear, theoretically by one-half.

Characteristics of three of Norden standard V-disc shaft position encoders:

MODEL	ADC-ST7-BNRY-X	ADC-13-BNRY-X	ADC-19-BNRY-X
Total count	2^7	2^{13}	2^{19}
Revolutions for full count	1	64	4,096
Accuracy—1 part in:	128	8,192	524,288
Length (less shaft extension and header)	1⅜″	2⅜″	3 19/64″
Life	$4X10^6$ revolutions at 200 rpm		
Diameter	1.750″		
Mounting	Size 18 Standard BuOrd Synchro Mounting		

LONGER LIFE—IMPROVED PERFORMANCE

- Three brushes in parallel for each contact reduces noise
- V-disc pattern and in-line brushes hold tighter switching angle tolerances
- Precious metal brushes mated to micro-finish pattern disc during run-in
- Meets Military Specifications MIL-E-5272A and MIL-E-5422D

RELIABILITY IS DESIGNED IN . . . AND BUILT IN BY UNUSUAL MANUFACTURING CONDITIONS

Scientists and military electronics experts testify to Norden's unusual quality control techniques. Encoder parts are manufactured, assembled, inspected and reinspected with extreme care in positive-pressure, dust-free, temperature-controlled laboratories. Norden's exceptional design and production facilities are the foundation of encoder reliability. Detailed manufacturing control specifications are available for your inspection.

Consider your requirements, then send for complete specifications and drawings for these or any other Norden encoders. Write or call Milford, Connecticut, TRinity 4-6721.

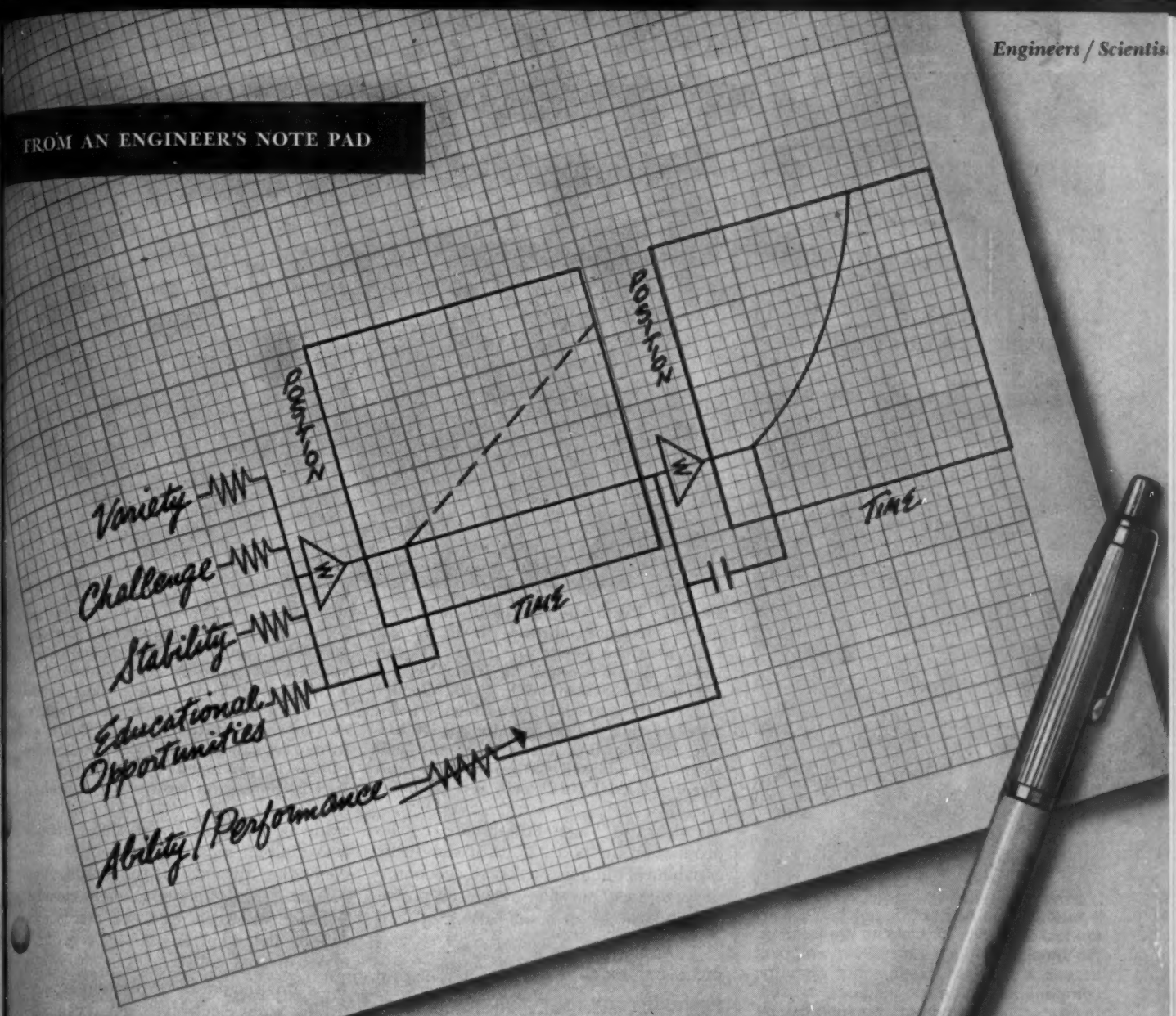
NORDEN

NORDEN DIVISION
UNITED AIRCRAFT CORPORATION
MILFORD DEPARTMENT, WILEY STREET, MILFORD, CONNECTICUT

CIRCLE NO. 31 ON INQUIRY CARD

CIRCLE NO. 141 ON INQUIRY

FROM AN ENGINEER'S NOTE PAD



"You plot your own curve at HMED"

ENGINEERS ARE a curious lot; a breed apart. Their natural preferences for facts, their talents for logic have been trained and disciplined.

The result many times...an uncommon, refreshing way of expressing the well known...a direct, succinct method of stating the complex.

Here is an actual example. It is a composite of sketches made by one of our Engineering Supervisors during a discussion of General Electric's unique Salary Administration Program.

Circuit engineers will have little trouble in reading it. Others may have more difficulty. All may wish additional detail. For this, as well as other information regarding the unusual professional and outstanding personal opportunities awaiting you at General Electric's Heavy Military Electronics Department, write in confidence to George B. Callender.

HEAVY MILITARY ELECTRONICS DEPARTMENT

GENERAL ELECTRIC

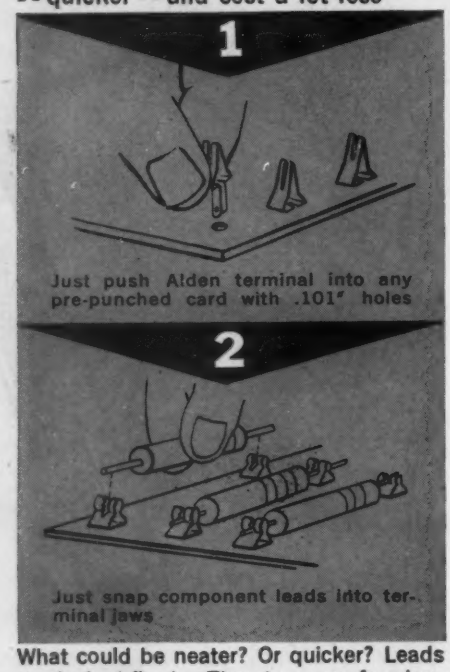
Div. 29MH, Syracuse, New York

There are openings for graduate engineers at intermediate (3 or more years) and high levels of experience in the following areas: Weapons Systems Analysis; Mathematical Analysis of Engineering Problems; Military Communications Systems; Radar Systems; Weapons Control Systems; Electronic Circuitry; Experimental Psychology—Human Factors; Instrumentation.

ALDEN

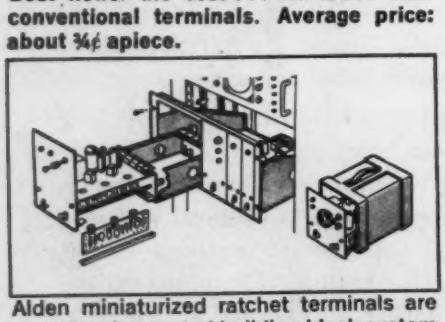
miniature ratchet terminals

For mounting circuitry, they're neater -- quicker -- and cost a lot less



What could be neater? Or quicker? Leads are locked firmly. There's no pre-forming. No feeding through holes. No wrapping around a post. In experimental circuitry, components can be snapped out, re-used. In production equipment, terminals can be staked quickly, automatically or by hand. Components can be mounted in place and soldered on production line basis. Heat is dissipated faster — in the terminal, not in the component.

Best news: the cost . . . far lower than conventional terminals. Average price: about ¾¢ apiece.



Alden miniaturized ratchet terminals are part of an integrated building block system that lets you lay out and package a single unit or a complete electronics system with "off-the-shelf" Alden components for plug-in, modular construction.

For complete information, write:

ALDEN

PRODUCTS COMPANY

8138 North Main Street, Brockton, Mass.

CIRCLE NO. 53 ON INQUIRY CARD

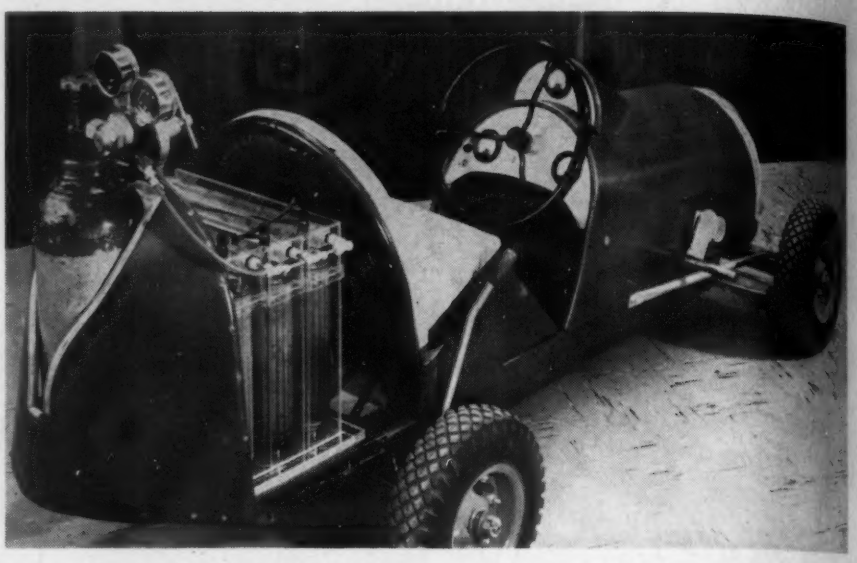


Fig. 1. Prototype fuel cell, which produces electricity directly from chemicals, provides power for racer. Of unusual, simple design, the zinc-oxygen cell will be developed first for electric industrial material handling trucks. After testing in rugged, long-shift lifting and hauling operations, the cell might be adapted to automobiles and street trucks. Exide's cell, several times more powerful per cu. ft. than any fuel cell yet demonstrated, conceivably could be used in smog-free, nearly silent vehicles as large as conventional ones, with speeds and driving ranges adequate for modern-day needs. Tank at end of racer contains oxygen that is admitted by low pressure to the cell where power is produced by oxidizing zinc fuel in potassium hydroxide electrolyte.

cal size and being adaptable to mass production methods. Thus, it should be capable of being packaged economically to meet a wide range of power demands.

CELL DETAILS

Fuel cells, essentially advanced types of storage batteries, are capable of power efficiencies at least double the 40 percent maximum efficiencies of the best conventional engines and generators. They have no need for intermediate steps of combustion or steam production with resulting losses of power through heat or friction. In Exide's zinc-oxygen cell, zinc is oxidized in a potassium hydroxide electrolyte as oxygen is admitted under low pressure. Exide predicts that such a cell will provide enough power to keep an electric industrial truck going continuously in heaviest-duty service for 16 to 24 hours before the fuel cell would need to be recharged. This particular Exide zinc-oxygen cell can be reversed (recharged electrically) to restore its full power potential, eliminating any need to remove waste products, a serious problem in the practical development of other types of fuel cells.

If, on the other hand, the vehicle operates continuously, another design can be used in which the zinc electrode can be removed and charged outside the cell or replaced. The zinc oxide of the discharged zinc electrode is valuable recoverable material and could be turned in for credit, thus reducing cost of a replacement element.

Exide states its first cell resists conditions that shorten the lives of other types of fuel cells:

- is unaffected by saturation of electrodes with electrolyte if oxygen supply is low or cut off;
- will operate efficiently at high current densities;
- avoids excessive corrosion caused in other types of cells by high temperatures and pressures;
- has elements that are stronger, of more rugged construction, for life longer than most other fuel cells.

The elements of the zinc-oxygen cell also promise to speed the development of several other fuel-cell systems by Exide because they:

- have higher electrical conductivity than those of other fuel cells;
- have more uniform reactivity over the current-producing surfaces;
- can be produced in a variety of shapes, thus adaptable to many fuel-cell designs;
- are capable of being mass produced.

At this comparatively early stage of development, Exide believes that its zinc-oxygen cell will cost less to own and operate in industrial material handling equipment than gas or propane-power units.

This servo package gives electrical readouts of airspeed in terms of N-S and E-W components when supplied with synchro inputs consisting of a compass heading, magnetic variation and Doppler ground speed.

NOW BUY cppc QUALITY ACCURACY RELIABILITY

IN cppc SERVO MODULES

In designing and producing servo modules to *your* specifications, Clifton Precision Products Co. manufactures 95% of the parts used. What does this mean to you? It means that the same high accuracy, reliability, and quality which go into the manufacture of CPPC synchros are maintained in CPPC Systems. This one source responsibility gives you the added advantage of a continuous Quality Control activity which guarantees a high quality product.

CPPC has had years of broad experience in researching, designing, developing, and manufacturing a wide variety of servo packages. A few examples of our products are shown on this page. Here at your service is a first class engineering design and manufacturing team from research through production.

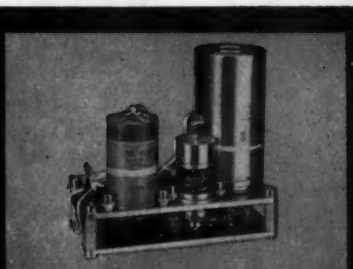
Write for a more detailed facilities brochure or telephone Ken McGrath, Sales Department, HIlltop 9-1200 or our Representatives.

cppc SYSTEMS DIVISION

CLIFTON PRECISION PRODUCTS CO., INC.

Clifton Heights **Pennsylvania**

This "Synchronizer Drive" servo package is used to null out gyro signals before an aircraft's autopilot is engaged.



This "Synchronizer Drive" can be used to null out transmitter signals. A wide variety of gear ratios is available as well as the option of two speed operation.

This transducer servo package converts a mechanical shaft input into a linear precise electrical output when a 28v dc signal is applied. It is particularly useful in aircraft for position information transmission of air surface controls.

CIRCLE NO. 25 ON INQUIRY CARD

ELECTRO-PNEUMATIC CIRCUITS

Fast-acting Air Valves Operate Differential Cylinder

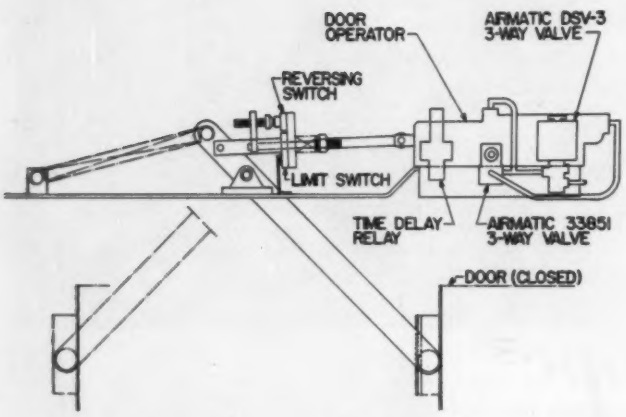


Fig. 1 Door operator for the end doors is controlled by an Airmatic DSV-3 valve and an Airmatic 33851 valve. A clevis mounted on the end of the piston rod applies pressure to the arm that closes the door. The DSV-3 valve (normally closed) is energized continuously holding the valve open. Valve 33851 is normally open. When it is not energized, air passes through to the right side of the cylinder. To open the door, the time delay relay is energized which in turn energizes valve 33851. When this valve closes, all the air is directed to the left end of the cylinder and the piston is exhausted through the 33851 valve. When the 33851 valve is de-energized, it opens and part of the air supply again goes to the right end of the differential cylinder and the balance of pressure forces the door closed. Two springs, one in tension and one in compression, hold the door closed in case of either air or power cut-off.

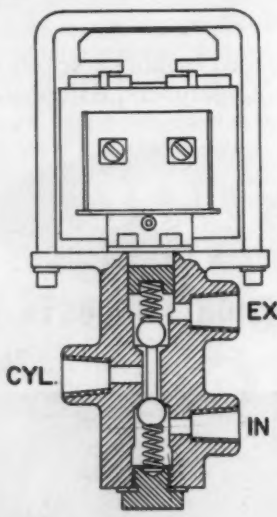


Fig. 2 The Airmatic DSV-3 valve, normally closed, supplies air to the door operator. The valve, energized continuously while the train is operated, is designed for long life by eliminating sliding parts and rubber or composition seals. Two stainless steel balls that fit into precision ground valve body seats function as seals. When the valve is closed, air provides positive shut-off equal to a ball check valve. At the same time, a floating pin held between the two balls opens the cylinder port to exhaust. Valve does not depend on spring pressure to seal. The higher the pressure, the better the seal.

Safety, reliability and ease of operation were the major design criteria in the development of an automatic control system for passenger-operated doors in railway cars.

To achieve these goals, the controls had to be such that;

- the door would be normally closed.
- a push button opens the door.
- the conductor could open door and hold it open upon arrival at station.
- Door closes automatically after passenger walks through.
- door has a reversing switch.
- door remains closed during power failure.

Door operators, based on the differential cylinder principle, were designed by Owosso Div. of Midland-Ross Corp., Owosso, Mich. The door operator for the end doors is shown in Fig. 1. Two Airmatic valves that control the differential cylinder are shown in Figs. 2 and 3.

CONTROL CIRCUITS

End doors and the vestibule doors have similar electrical systems, as shown in Fig. 4. When the conductor sets a double throw, double pole switch to automatic operation, the DSV-3 valve is energized and is in the open position; the 33851 valve normally opened, is not energized. Under these conditions the door is held shut.

When a passenger wants to pass through the door he presses a button which energizes a time delay relay which in turn energizes the 33851 valve. The door opens in three seconds, the relay holds it open for one second and then cuts out which de-energizes the 33851 valve and the door closes. Should the door strike an object while closing, a reversing switch is closed which completes the energizing circuit for the relay, permitting the door to open instead of continuing to close. The reversing switch completes the circuit in the same manner as the passenger switch.

When the train has come to a stop and the conductor

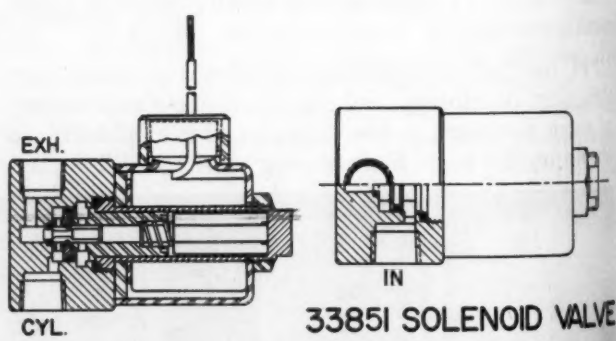


Fig. 3 Path of air in the door operator is controlled by Airmatic 33851 solenoid valve. Air enters at "In" and passes through to the cylinder. When the valve is activated the plunger moves down which prevents air from passing through the valve. While the valve is closed, air from the cylinder can exhaust through. Containing only two moving parts, the spool and the spring, valve has a life of over 20,000,000 cycles under normal operating conditions. Maximum operating pressure: 200 psi with a 1/8 in orifice; inrush current: 0.218 amp; holding current: 0.309 amp.

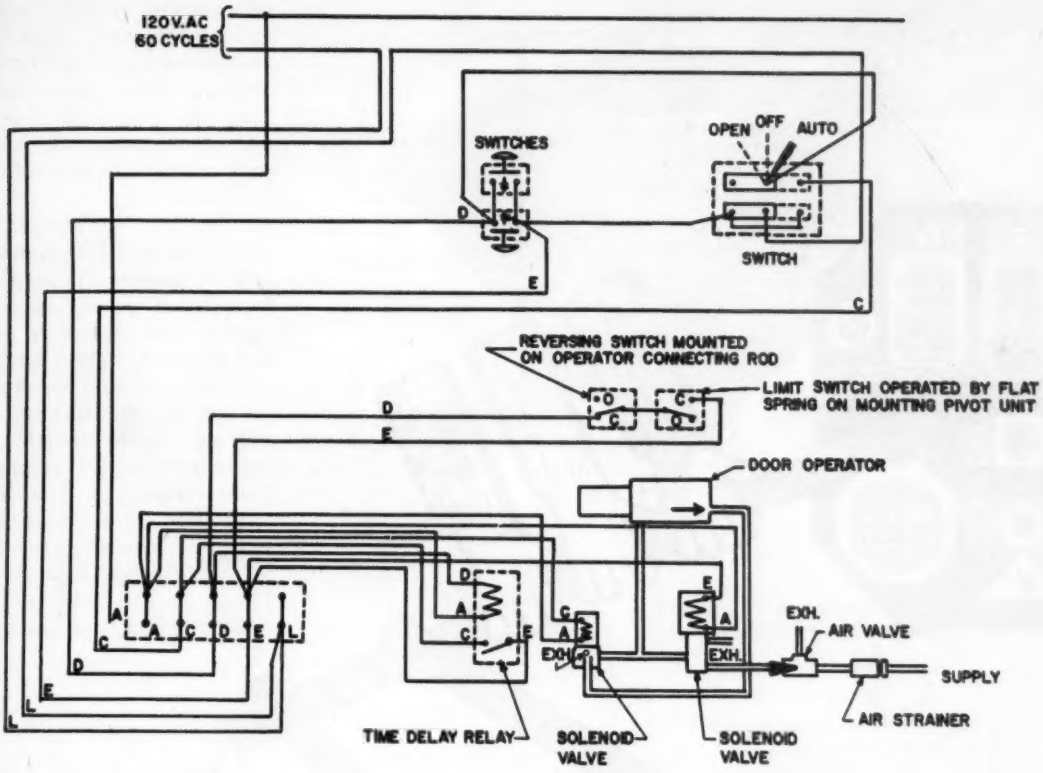


Fig. 4 Double throw, double pole switch set by conductor is at the upper right; button operated by the passengers is at top center. DSV-3 solenoid valve is directly below the door operator; 33851 solenoid valve, controlled by a time delay relay, is at the left. When the switch is on automatic, the DSV-3 valve is energized and held open. The 33851 valve is normally open when not energized. Hence air is directed to both sides of the cylinder and the balance of pressures holds the car door closed. When a passenger presses the button switch, the time delay relay and the 33851 valve solenoid are energized, closing the valve; all of the air goes into one side of the door operator cylinder and the door opens. When the time delay relay cuts out the 33851 valve, the door closes. Should it strike an obstruction a connection is again made from D to E and the door opens. The limit switch is open only when the door is completely closed. When the conductor's switch is on open and the passenger button is depressed, the time delay relay is continuously energized and the door is held open until the conductor switch is moved to off or automatic.

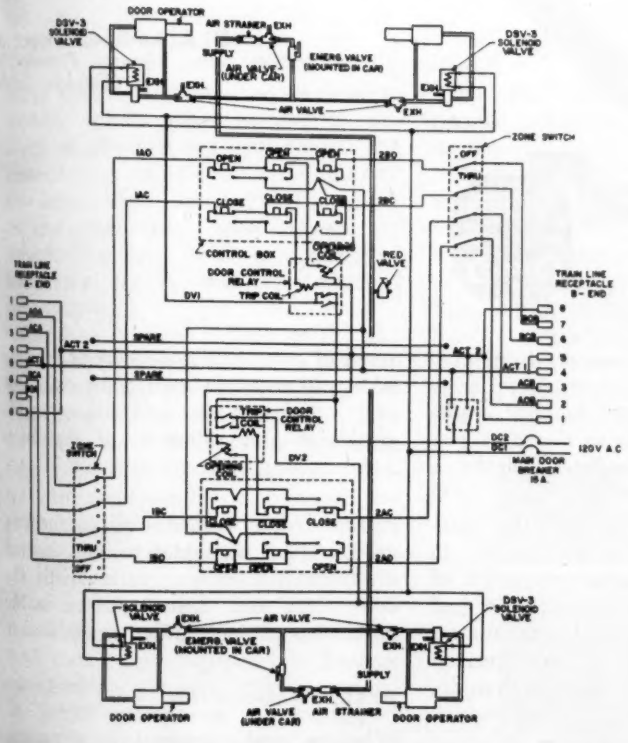


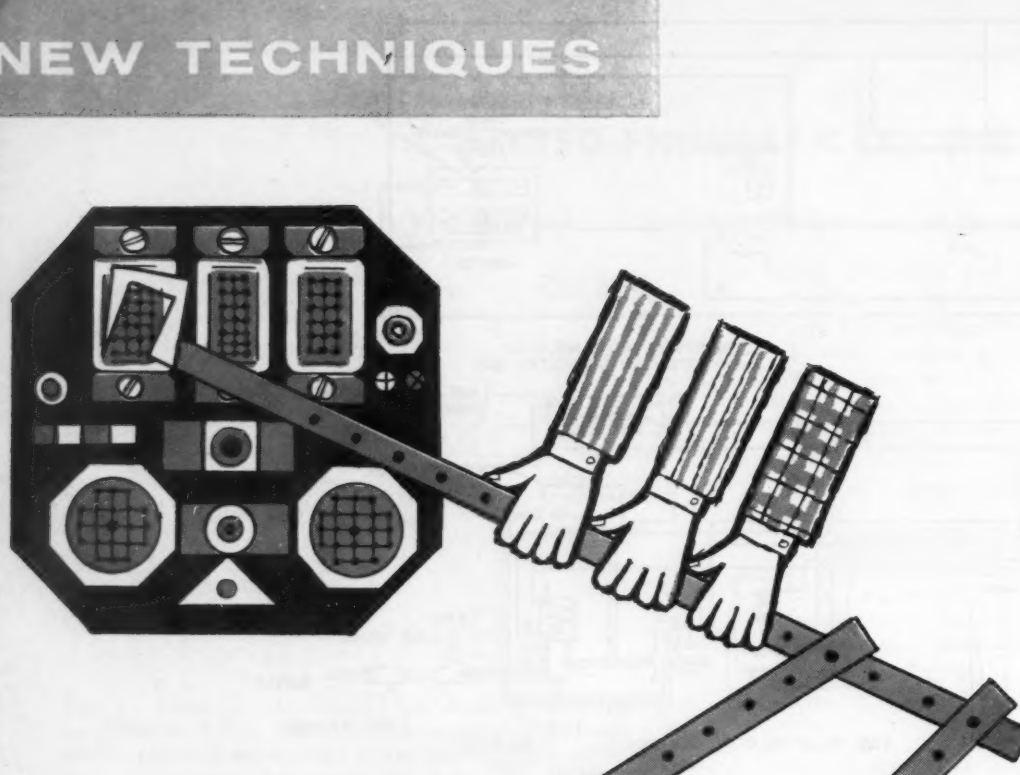
Fig. 5 Hydraulic and electrical circuits for the center doors are controlled by the conductor. One car is designated (by setting the zone switch) as the one from which the conductor will control all the center doors. With this system, the conductor can open and close the doors of the car he is in, those of all cars ahead or back, or all the cars at once. Doors can be operated from a different car by changing zone switches.

wants the doors to remain open, he throws his switch to "open", and pushes the passenger switch. The door is held open after the pushbutton has been released because (with the switch on open) the time delay relay continues to activate itself. To close the door, it is necessary to turn the conductor switch to off or to automatic. In either case, should the door meet an obstruction, the door will reverse because the reversing switch will close.

The circuit which includes the reversing switch also includes a limit switch that opens just as the door closes. This keeps the door from re-opening as soon as it closes.

For center doors, the control system (Fig. 5) is modified since only conductor control is needed. One car is designated (by setting the zone switch) as the one from which the conductor will control the opening and closing of the doors. If desired, the conductor can change the zone switch (while the train is en route) and operate the doors from another car. The door operator is also a differential cylinder but because passengers do not operate these doors, only one solenoid valve is needed.

For More Information on Airmatic Valves:
Write No. 204 in Box on Inquiry Card



Designing Fo Mini

D. A. Ladine, *Project M*
Librascope Div., General Precision, In
Glendale, Califor

"Integrated miniaturization", a technique developed at Librascope, may be described as a design approach which focuses the talents of the system, electrical and mechanical engineers on the total project, from conception to final hardware, in order to achieve the most performance, reliability and ruggedness in the least possible space and weight. Thereby a team of engineers is developed who are not only familiar with their own specialty, but are also well versed in the problems and solutions of the interface regions between specialties.

Equipment has become so complex and techniques of solution have become so elaborate that the application of skill from any single engineering area cannot cope with the entire design. The design, then, must depend upon the combined efforts of many specialists. Unfortunately, the result too often follows a pattern of isolated engineering development and packaging design. Mechanical, electronic and system requirements are solved independently with many of the interface problems of interconnection and mating ignored until the end. This inevitably results in wasted time, duplication of efforts and possible over-design. Each isolated design group is aware only of its own problems and has no real understanding of the other's problems.

An essential element of the integrated approach is to get people to think in terms of the requirements of the end product. Of course, this goal has always been desirable, no matter what the product. In miniaturized equipment, however, it is more than desirable—it is essential.

ORGANIZATION

Librascope organized the engineering department into project groups, each of which consists of engineering talents in varied fields. These teams of engineers are directed by project managers whose technical backgrounds represent a variety of skills. This organization deviated from the previous concept of all projects being solely directed by a mechanical engineering group. The organization and control of individual teams varies with the complexity and skills involved in the particular project under consideration.

DESIGN PROCEDURE

When a new proposal is requested, the governing specifications are reviewed by the project managers. Following this review, the project team considered most suitable is assigned the task of preparing the proposal and the required follow-up. During the proposal preparation the team tentatively assigns tasks and reviews the possible areas where interface conflicts might occur, concurrent with formulating the design concepts and approach.

The "interface" factor presents the design group with the problem of successfully satisfying requirements in each of the technical areas involved without adversely affecting the performance of any one element of the design or of the overall system performance.

When the proposal is accepted the same project team will undertake the equipment design, development and preproduction tasks. Due to the elapsed time between proposal and acceptance, the original design concepts and the overall approach are reviewed by the project team. Checkpoints are established at different stages for the project's development. Each team member is then allowed to progress more or less independently until each successive checkpoint is reached. At the checkpoints, a careful re-evaluation of the design goals, in terms of recent progress, is made. The various alternative design tangents that each team member might have uncovered between checkpoints are considered. The consequences of these variations on the design approaches and the effect on the other team members are resolved. This may result in a modified formulation for the ensuing design of the equipment.

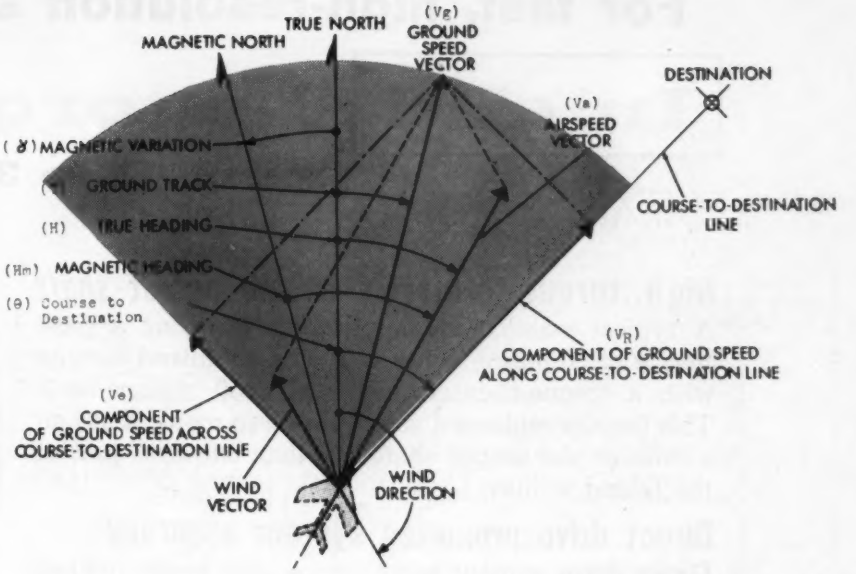


Fig. 1 Vector diagram illustrates the operational parameters of the computing problem.

Miniaturization

Checkpoints are designated and monitored, not only for the purpose of charting and controlling project design, but to effectively bridge the gaps between the different engineering fields. This actually allows the different team members to complement one another in the interface areas. Control can easily be maintained by the project manager at these checkpoints. However, the project manager's guidance and control problems are eased, since each team member has become more aware of the other's problems and has gained proficiency in working as a team, to the point where many of the solutions to the interface problems become intuitive.

The approach as outlined is important in normal product design. However, when designing for miniaturization a higher order of coordination, "complete" design integration, is required. It even becomes impossible to describe the electrical, mechanical, and packaging problems separately, for there is always the pressure of space limitations to a degree completely unknown in ordinary product design.

It is apparent that the knowledge acquired through group approach will develop personnel with more rounded backgrounds, thereby developing know-how and techniques for handling future design problems. Another advantage of this approach is the automatic cooperation that exists between what were formerly considered antagonistic design groups. Once organized and functioning, a group is capable of limited loss and replacement of personnel without a reduction in output.

Application of this approach to system, sub-system and component design are described in the following examples.

SYSTEMS APPLICATION

A navigational computer that presents direct readings of position in terms of range and bearing to destination dem-

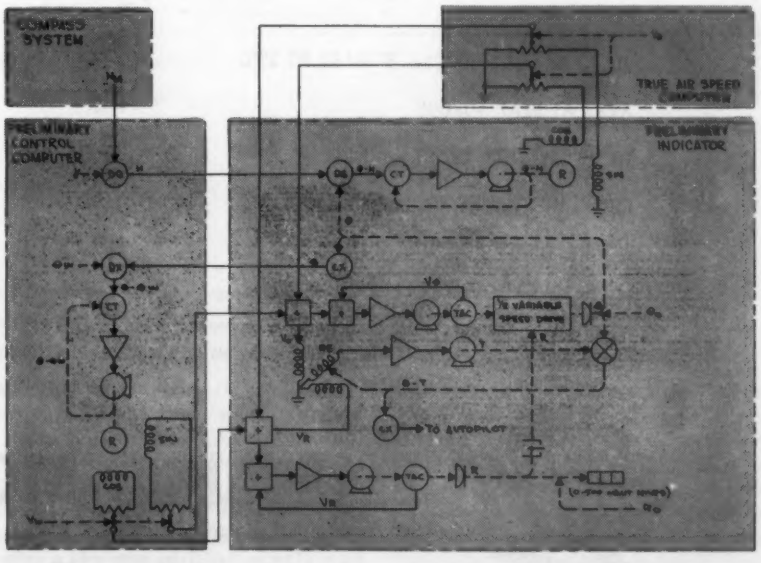


Fig. 2 Preliminary block diagram of the navigational computer.

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VOLTS AT PEAK TORQUE, STALLED AT 25°C	31.4	24.8	39.6
AMPS AT PEAK TORQUE	1.82	2.25	1.46
TOTAL FRICTION, OZ.-IN.	0.5	0.5	0.5
ROTOR INERTIA, OZ.-IN. SEC.^{2}	.001	.001	.001
WEIGHT, OUNCES	5	5	5

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Inland makes a complete line of power amplifiers for systems duty with Inland torquers whether in airborne, shipboard, or ground service. Specification sheets available on request.

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Factory: Radford, Virginia

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onstrates the application of the integrated design approach to a complete system. System simplicity and compactness were the major considerations in this design. Computer accuracy had to be compatible with the accuracy of currently available heading and speed sensors.

To such a computer, the destination is a specific point, with a bearing and range related to the instantaneous position of the aircraft. Automatic inputs of true air speed and heading and manual inputs of magnetic variation and wind were employed in the computation of the aircraft's position. Results must be presented as course and distance to destination. At the same time, ground track must continually be computed and displayed by the instrument.

The vector diagram, Fig. 1, shows the operational parameters of the problem. The initial design conferences had as their goal the most direct and simplest mathematical approach to the solution in terms of feasible computing elements. The following equations represent the vectors and vector computations decided upon as the optimum mathematical structure.

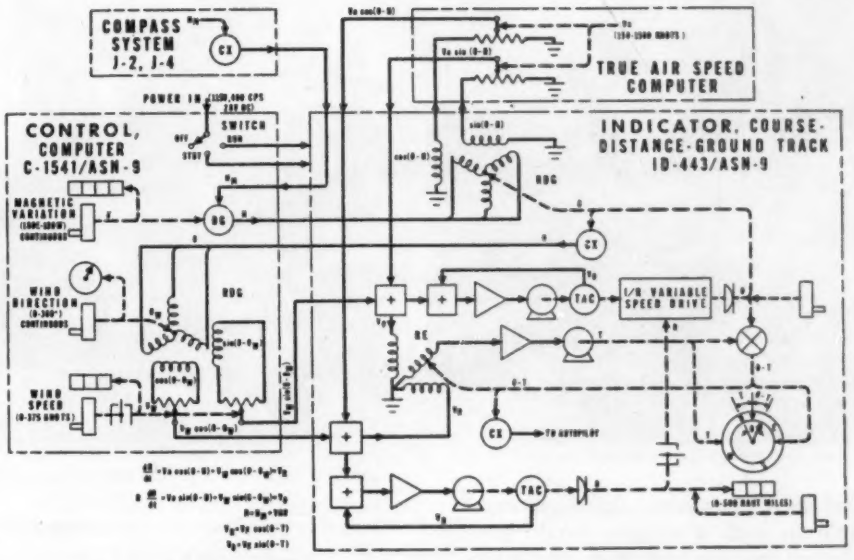


Fig. 3 Final block diagram of the AN/ASN-9 Navigational Computer.

$$V_R = dR/dt = V_a \cos(\theta - H) + V_w \cos(\theta - \theta_w)$$
$$V_R = V_g \cos(\theta - T)$$
$$V_\theta = Rd\theta/dt = V_a \sin(\theta - H) - V_w \sin(\theta - \theta_w)$$
$$V_\theta = V_g \sin(\theta - T)$$
$$H = H_w + \sigma$$

Since the pilot display was the end objective, the first step in attempting to miniaturize the design, was to eliminate the redundancy that exists in remote display equipment by integrating the computer and the indicator into a single package. The preliminary block diagram shown in Fig. 2 represents a computer that solves the given equations. It was obvious from

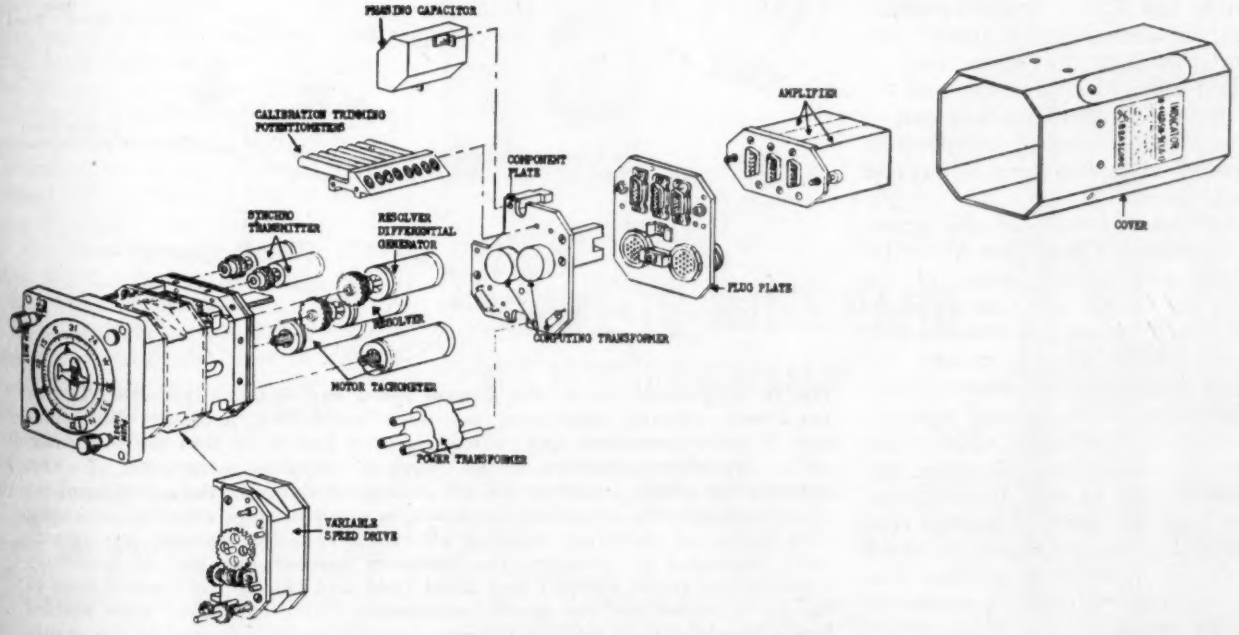


Fig. 4 Exploded view of the computer. Because of the close liaison between the engineers and packaging designers, several problems were solved through an integrated approach to physical and functional design The actual physical position of the divider and variable speed drive was planned to provide an effective thermal transfer path between the heat producing elements and the instrument case, which is used as a radiating surface. An additional dividend of the team effort was that the divider also provided a structural support in the final package thus increasing the overall mechanical stability of the computer without sacrifice of weight or space. Additional space economy was achieved through the group's net efforts thus leaving room for miniaturized amplifiers. These were plugged directly into the indicator unit, reducing signal load lengths, and permitting reduction of control unit which had originally been planned for housing of amplifiers. Phasing capacitor unit had to be packaged into an 8-sided shell.

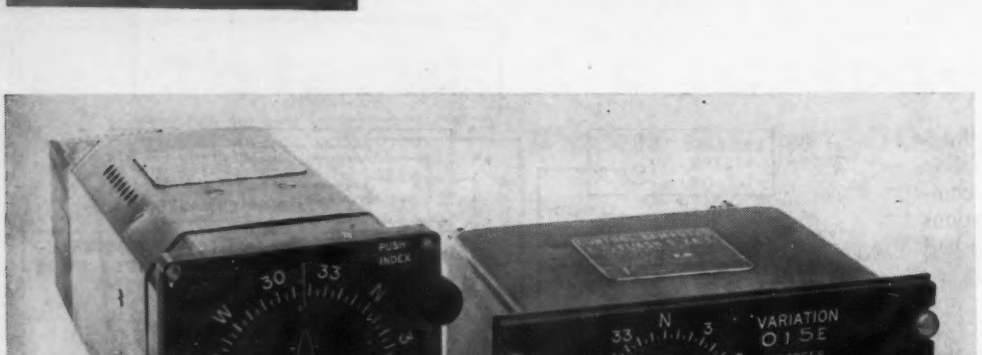


Fig. 5 Final computer unit (left) weighed 30% below the minimum weight requirements. The associated control unit is shown on the right.

the start, however, that a computer built in such a manner would greatly exceed the size and cost specifications laid down for this project.

The first major reduction in size was through a re-evaluation of computing elements. Development of an original synchro element to combine the functions of angle summation and vector resolution made possible the elimination of two complete servo loops from the computing mechanism. The simplified functional block diagram incorporating this change is shown in Fig. 3. The synchro element, defined as a resolver differential generator, combines the stator from a standard differential generator and the rotor from a standard resolver unit to eliminate ten computing components: six synchro units, two servo motors and two amplifiers.

From the beginning of the actual development, the need for a divider on the rotating shaft output of the $Rd\theta/dt$ computing loop was apparent. Development of such a division system was difficult not only because the unit had to divide a time varying product by a term which in itself was also a function of time but in addition the range of variables was extensive, approximately 500 to one. Investigation, by the team members, of various conventional dividing techniques indicated that drastic increases in physical size would be required with increases in operating range.

The final divider design was a miniature, variable speed, mechanical system incorporating a series of ball and disk drives and operated by a specially designed cam, whose follower transmits the second power of the time varying divisor to the ball and disk drive. The shaft speed output represents the quotient. This design sequence illustrates the manner in which an integrated team effort permitted the transfer of what had originally been a control problem to the mechanical engineer, resulting in a different mode of approach.

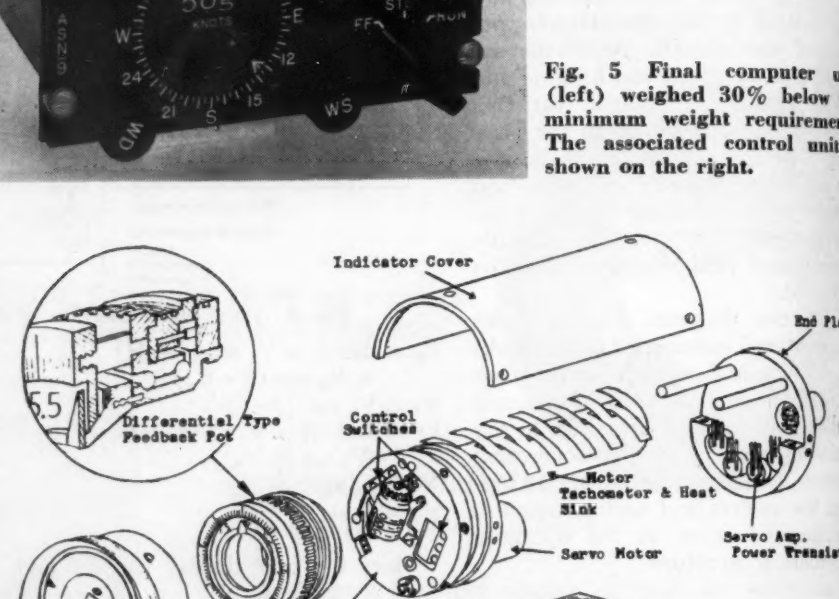


Fig. 6 Exploded view of the ground speed and distance indicator. Tuning capacitors, phasing capacitors, two servo amplifiers, necessary heat sinks and the interconnection and control circuitry had to fit into the lower rear cavity. Optimum amplifier design required complete integration of effort between the circuit engineer and the package designer in the selection of the circuit components and their placement, in order to allow effective packaging with minimum electrical coupling effects. A capacitor module was specifically developed to overcome the relatively cumbersome size of capacitors required for phase shifting and fixed field and tuning the control field of the servo motor and the motor tachometer. These capacitors were molded into a single unit to fit into the rear housing cavity adjacent to the amplifier modules.

Simplifications also occurred in the several summing devices. After a thorough group evaluation of electronic, electromechanical and purely mechanical summing methods, the team de-

cided that a miniature mechanical differential, working in conjunction with the differential action of the track and course dial assembly, gave the necessary accuracies with an absolute minimum volume.

For voltage summation, as in summing true air speed and wind speed signals, an obvious choice would have been one of the many existing forms of resistance summing. However, loading effects and gain attenuation, along with the necessity of incorporating a more expensive amplifier system in each loop, made such methods impractical. A miniature computing transformer, wound so that its output signal represented the sum of the input quantities, avoided these drawbacks.

The computer embodies the collective thinking of a group who worked together with no definite distinction between mechanical or electrical assignments. An exploded view of the computer unit is shown in Fig. 4 and Fig. 5 shows an external view of the computer and the associated control unit.

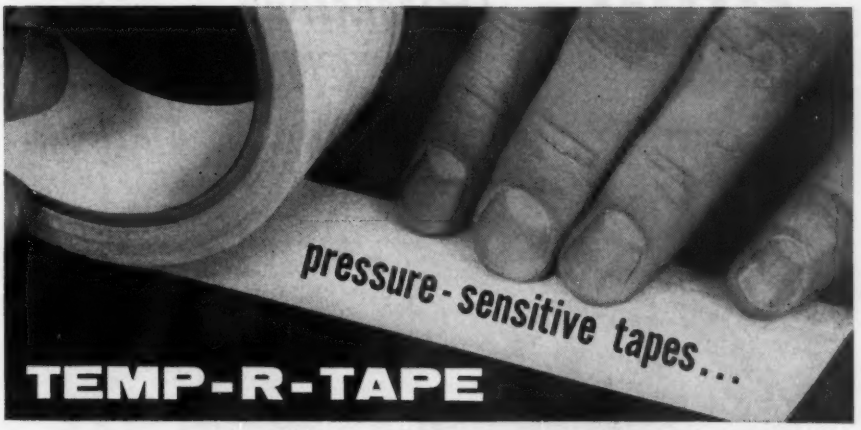
A SUB-SYSTEM APPLICATION

The severest test of the integrated design concept is in its application to the design of miniature equipment which must, of necessity, utilize non-miniaturized elements. A typical example is the development of a ground speed and distance indicator with rigid accuracy requirements and severe space limitations.

The indicator displays distance and ground speed information which established the point of weapons release as a function of distance from target. Its inputs were ground speed and, in case of ground speed signal failure, a true air speed signal. The unit had to continuously display the ground speed data and simultaneously integrate the ground speed signal to determine and display distance to release point.

Originally these functions were accomplished through the pilot flying a set constant speed course to target and determining the release point by means of an interval timer. This burdened the pilot with the problem of maintaining a constant speed under adverse attack conditions.

Upon the decision to replace the timer with a more sophisticated device which would permit flying at varying speeds, the equipment design group was faced with space restrictions caused by the necessity to fit the new instrument into the envelope formerly occupied by the interval timer. The permissible envelope was 2.25 inches in diameter by less than six inches in length. Fig. 6 is an exploded view of the indicator.



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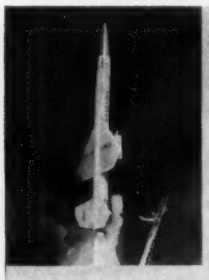

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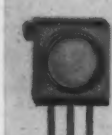

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Fig. 7 Ground speed and distance indicator. Throughout the design phase of this indicator, a continued joint effort was necessary in order to overcome the packaging problems resulting from space limitations; inductive or capacitive coupling due to circuit layout, ease of maintenance requirements and accessibility of test points.

The initial design conference resolved that the unit should consist of an integrator servo loop and a position servo loop driving the pilot display. Tests revealed that the only integrating method that could provide the required accuracy and reliability over the wide range of environmental conditions and power variations was a high precision, temperature compensated motor tachometer. The smallest motor tachometer, available at the time, capable of satisfactorily performing the integrating function had a diameter of half the envelope diameter and a length of two-thirds the envelope length.

The speed dial had to be manually adjustable with reference to a fixed fiducial on the case. This necessitated some sort of differential mechanism between the speed dial and the feedback pot in the position loop. Achieving the desired accuracy within the specified space demanded a new kind of pot design since the diameter of a conventional pot would be far too large. The final solution was a ring type potentiometer with the speed dial permanently attached to its mandrel by means of a suitable housing, and the speed pointer permanently affixed to its wiper arm. A bearing race was incorporated into the housing of both assemblies, with a hobbed gear on each housing. This design yielded a compact and accurate differential feedback element.

On-off and power failure flags required solenoid operation. At this point of design, available forward space within the envelope had been reduced to the minimum, thus precluding use of commercially available instrument solenoids. A special ring-type solenoid

and associated circuit was constructed. For maximum compactness, a transistor circuit was used as a relay.

Due to the desired compactness of the unit, heat generation and its dissipation was an important factor which affected the entire design from the project's start. Two major sources of heat generation required special attention; the motor tachometer and output power transistors of both servo amps.

The motor tachometer was fitted with a beryllium copper sleeve incorporating many fingers projecting outwards. These fingers make spring contact with the indicator cover providing an effective heat transfer path. The conducting fingers maintain a favorable interior temperature, stabilizing other circuitry and increasing the operational accuracy of the instrument.

Early in the project, at one of the check points, an area of the end plate was set aside for the purpose of heat sinking the power transistors. The problem of electrically isolating the transistors was solved by fitting the transistors into special hard anodized aluminum caps which were in turn screwed into the end plate. In this manner, the entire indicator frame was used as a heat sink and electrical isolation was maintained. Fig. 7 is an external view of the indicator.

TRANSISTOR SERVO AMPLIFIERS

The miniature 501-1 "postage stamp" amplifier, first built and tested over three years ago represents one of the tightest miniaturization jobs undertaken. An amplifier with a maximum volume of 0.6 cu. in. (because of packaging specifications) and an output of the 1⅛ to 3 watts required to drive a size 8 motor, was unobtainable.

Re-examination of the system's requirements showed that since the null seeking servo would normally be operating at low power levels, ¾ watt would be ample for this application. A pair of medium power silicon transistors in a class "B" push-pull circuit provided sufficient power to drive the load under the new revised specifications. The finished potted unit, considerably different and smaller than originally visualized (total volume of only ⅝ cubic inch) delivered ¾ watts. A recently improved model with a size increase of barely 5%, has doubled the power output using the newer power transistors. This new unit drives a size 8 motor to its full rated capacity, thus expanding the application range of subminiature servo modules.

The 3 watt 503-1 and the improved 6 watt 506-1 models both utilize a transformer coupled circuit incorporating a silicon transistor preamplifier with

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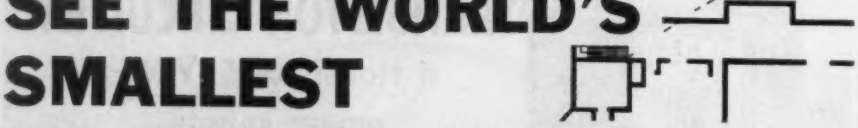

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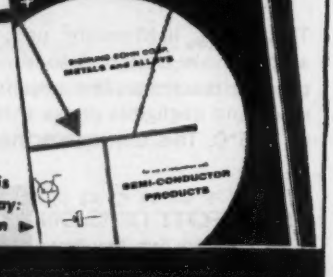

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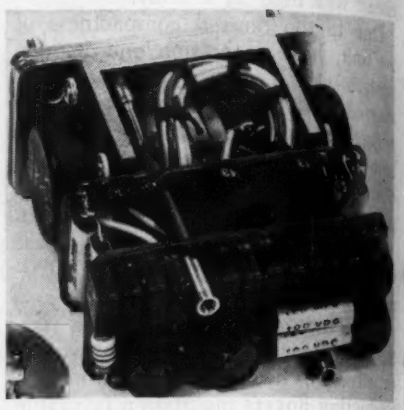

Fig. 8 High temperature, ten watt servo amplifier.

a push-pull Germanium power stage. A unique circuit layout employed common emitter operation of the stud mounted power transistors which were mounted in the same aluminum case for maximum heat dissipation and minimum size. Both collectors were electrically common and were connected to the dc ground. This was made possible by connecting the load to the emitter circuit and driving from two isolated windings of the driver transformer.

The input impedance, gain and drive levels are identical to the conventional common emitter stages. The 506-1 amplifier is a 2.5 cubic inch unit, potted in a finned, aluminum case; no additional heat sinking is necessary for operation up to 85C and electrical input is made through a miniature 9 pin connector.

At a higher level on the servo power spectrum, a 10 watt, high temperature servo amplifier, shown in Fig. 8, has been designed as a 4 cubic inch package, half of this volume being used to mount the awkwardly shaped silicon power transistors and the electrical connector. All other components and circuitry are contained in a 2 cubic inch printed circuit assembly. Close cooperation between the circuit engineer and the package designer resulted in the use of conventional circuits and available components; carefully chosen because of size requirements.

This servo amplifier had to be rated for a temperature range from –55 C to 100 C. Since suitable electrolytic capacitors were not available in sufficiently small sizes, reliable circuits which would operate with no by-pass capacitors or high valued coupling capacitors had to be designed. A Zener diode is used for a preamp decoupling filter, eliminating the need for large capacitors; temperature compensation makes use of thermistor and silicon sensitor elements.

Relay Analyzer

Various parameters such as coil resistance, pull-in voltage or current, drop-out voltage or current, pull-in time, or drop-out time can be measured on a relay analyzer. Lamps go on for "go" or "good" and remain off for "no go" or "bad." It is not necessary to read any meters or dials. Life testing may be performed at a controlled cycling rate. Five-way binding posts for all relay connections permit the use of an oscilloscope for contact bounce analysis and the application of loads on the relay contacts for load testing and contact resistance measurements. Molectronics Corp., South El Monte, Calif.

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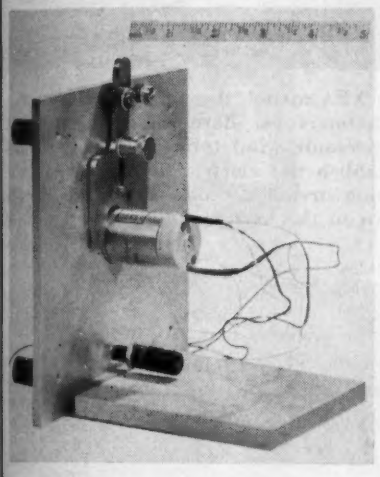

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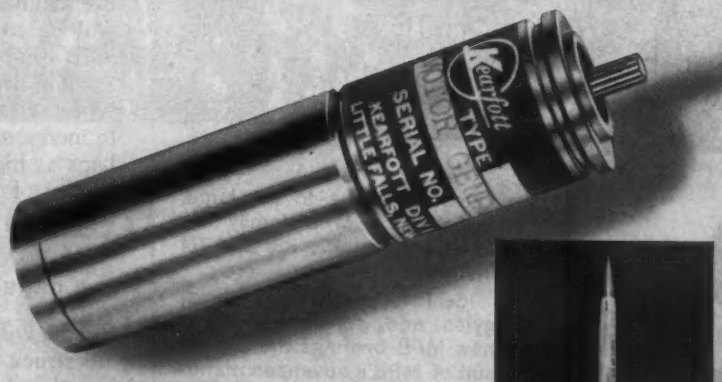

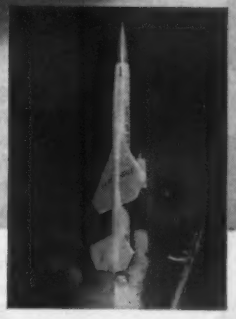

SIZE 8 MOTOR GENERATOR

Kearfott's new Size 8 high performance servo motor-generator features high signal output and extremely low null voltage. The signal-to-noise ratio of 100:1 and linearity of 0.2% make the application of this motor generator to lightweight integrator packages most desirable. Stainless steel construction and thermal stability assure its reliability and long life in the most severe environments.

KEARFOTT DIVISION
Little Falls, New Jersey

GP **GENERAL PRECISION, INC.**
Other Divisions: GPL, Librescope, Link

CIRCLE NO. 38 ON INQUIRY CARD

WIND TUNNEL DESIGN

"Crossed Field Acceleration"

Major advances in hypersonic wind tunnel design that are expected to provide a more flexible testing environment were revealed by Allis-Chalmers at the recent American Rocket Society meeting. Working with M H D Research, Inc. at Newport Beach, California, a Crossed-Field Acceleration test facility prototype is being developed to continuously simulate conditions encountered by ballistic missiles and space rockets.

Key to the Allis-Chalmers advance is the crossed-field accelerator which employs crossed magnetic and electric fields to further accelerate supersonic plasma coming from the generator. Substantiating the new concept in wind tunnel design, the prototype model has been operated for periods as long as twenty minutes. During tests with the prototype, the energy of a plasma stream has been increased by 60 percent with little or no increase in contamination.

Unlike many conventional wind tunnels, the Crossed-Field Acceleration tunnel will be capable of operating continuously at extremely high temperatures and velocities. Previously, blow-down tunnels have been used to simulate the conditions required to test materials for use in missiles. These tunnels usually operate for very short durations, on the order of milliseconds.

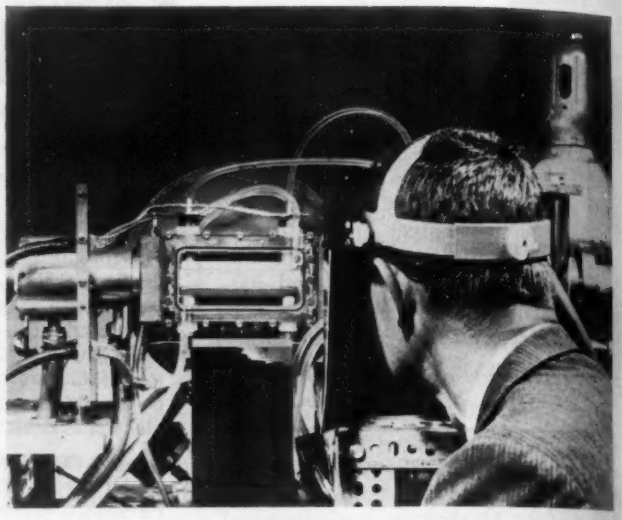

Fig. 1 Known as the XFA model, this laboratory prototype is utilized by Allis-Chalmers for development of *Crossed-Field Acceleration* hypersonic wind tunnels. The horizontal electrodes used to establish the electric field are visible on either eide of the plasma stream and one of the two circular magnetic coils is shown in the background.

PRODUCES VARIED CONDITIONS

In operation, the system will be used to produce a great many different conditions. Primary control of the system will be in the plasma generator unit. Specific enthalpy ranges and specific temperatures will be established by means of the power/gas ratio.

Secondary control will be in the accelerator. By varying the magnetic or electric fields, the accelerator input energy will be controlled. Electric field control will provide the most flexibility since it can be varied over a wider range.

The 60 percent energy increase obtained with the prototype indicates that a larger system would probably be able to increase the energy of the jet by a factor or two and perhaps as high as five. For higher energies, there is the possibility of using two or more crossed-field accelerators in tandem.

ARC GENERATES PLASMA

Plasma will be generated by passing gas through an electric arc struck between two electrodes. In passing through the arc, the gas will be heated to extremely high temperatures and partly ionized. The ionized gas will then pass through a convergent-divergent nozzle to be accelerated to supersonic velocities.

Additional power fed into the plasma stream by the accelerator goes both into accelerating the plasma (an increase in kinetic energy) and heating the plasma (an increase in internal energy). The relative magnitude of the heating and acceleration effects is dependent on several parameters including the electrical conductivity of the plasma stream and the magnitude of both the electric current and magnetic field.

The Allis-Chalmers accelerator will have double-walled, water-cooled viewing ports to allow visual and photographic observation of the plasma stream. Independent of other systems, the water for the accelerator cooling will flow slowly between the two transparent viewing plates on each side.

MPB announces...

3 new R's of instrument bearings

Latest additions to the large, fast-growing MPB family are ultra-precision R2, R3, and R4 instrument bearings.

Ideal for servos, synchros, gyros and generators, these new MPB bearings are the result of MPB's advanced manufacturing, thorough quality control and emphasis on precise, accurate bearing geometry.

Find out now how MPB bearings and technology can benefit your products. Call your MPB Sales Engineer or write for information. Miniature Precision Bearings, Inc., 1308 Precision Park, Keene, N. H.

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Helps you perform miracles in miniaturization

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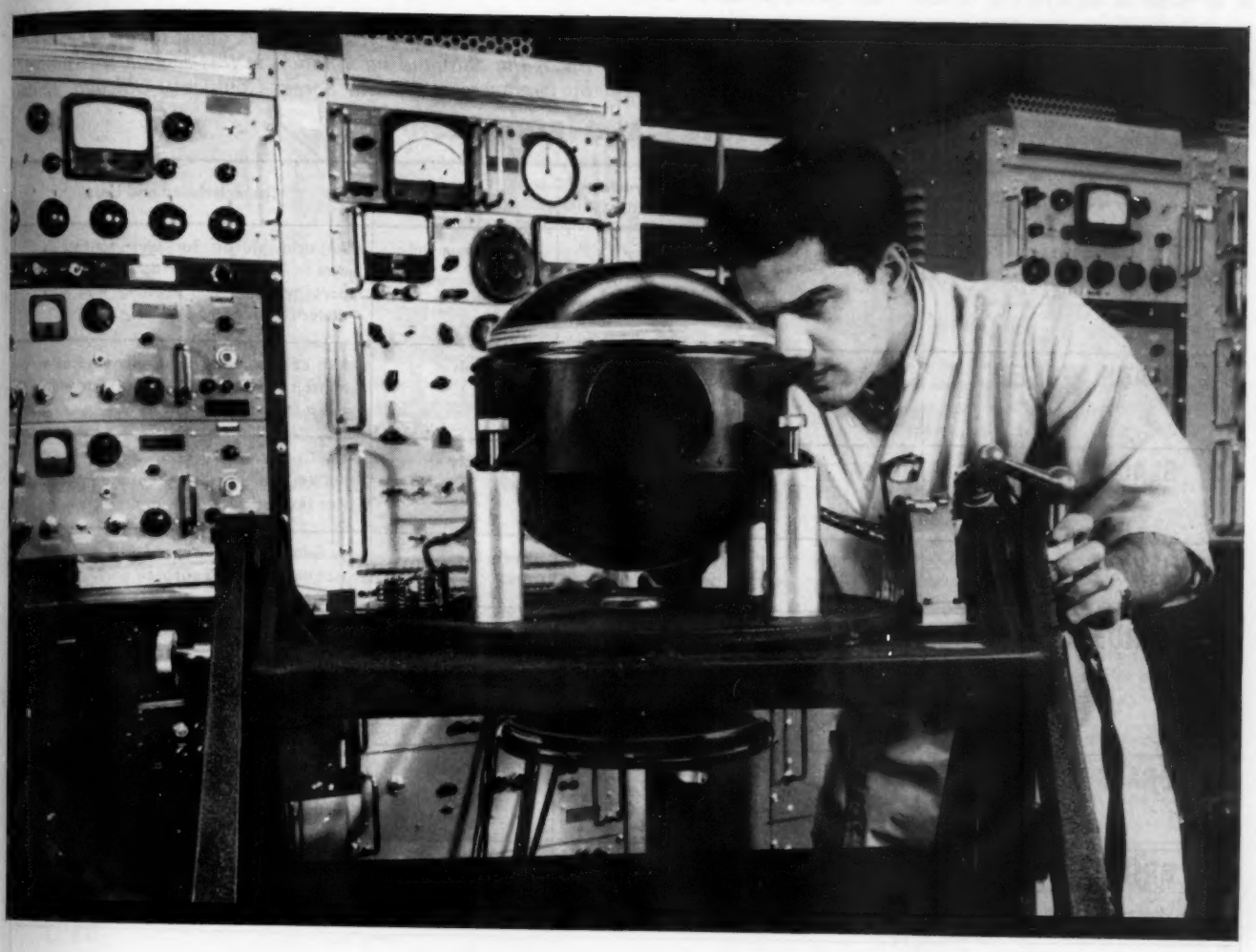
KEARFOTT is the world's largest producer of...



light-weight

schuler-tuned

3 GYRO PLATFORM SYSTEMS

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Little Falls, New Jersey

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DESIGN TIME SAVER

FASTENING DESIGNS

PLATINGS
FINISHES
HEAD TERMINOLOGY
POINT TERMINOLOGY

Part I (Fastening Designs for Speed, Inserts, Safety, Simplicity, Appearance, Adjustment and Sealing) appeared last May. In Part II we present pertinent fastener information associated with the selection and application of fasteners. All of the data and information in this section was prepared by engineers at Central Screw Company, Chicago, Illinois.

PLATINGS AND FINISHES

FINISH	Color	Anti-Corrosion Properties	Suitability	Characteristics and Uses
ANNODIZING (Aluminiting)	Yellowish Silver Cast	Excellent	AluminumOnly	An acid plating for aluminum which acts to harden the surface and reduce porosity. Abrasion resisting with high dielectric strength.
BLACK NICKEL	Black	Excellent	All Metals	Rich and lustrous. Generally used as a matching finish. Supplied with or without a lacquer coating.
BLACK ZINC	Black	Excellent	All Metals	The same characteristics as BLACK NICKEL with a slightly greater degree of rust resistance.
BLUING	Clean Blue	None	Carb. Steels Only	A coloring process produced by heat treating. For appearance only.
BONDERIZING	Dull Gray	Excellent	Ferrous Metals	A chemical process for rust-proofing steel and supplying an ideal base for paint or enamel. Can also be applied to galvanized, zinc alloy and cadmium surfaces.
BRASS	Brass	Good	Usually Steel	Most frequently applied to steel for purposes of matching brass. Supplied dull or burnished.
BRIGHT POLISH	.....	None	All Metals	A cleaning operation by barrel tumbling for removing oil, scale, etc. from metal parts.
BRONZES 1. Brite Copper Oxid. 2. Dull Copper Oxid. 3. Statuary Bronze 4. Antique Bronze 5. Black Oxidized	Ranging from bright straw to dull black copper	Fair	All Metals	Usually applied as decorative finishes for accurately matching wood colors: radio cabinets, desks etc.
CADMIUM (Udilyting)	Silvery Gray (Dull or Burnished)	Excellent	All Metals	A non-porous metallic sheathing. Most widely used plating because of rich appearance, fine rust resisting qualities and economical cost. Good electrical conductivity quality.
CARBON BLACK	Black	Slight	Brass	An economical, rich black finish applied to brass for purposes of matching color.
CHROMIUM	Brite Blue White	Excellent	All Metals	A bright, lustrous finish used where the ultimate in beauty of appearance is desired. Substantially weather-proof.
COPPER	Copper	Fair	All Metals	Commonly used as an undercoating for nickel or for decorative purposes.
DICHROMATE DIP	Rainbow Cast	Excellent	All Metals	A dipping process added to Zinc or Cadmium plating which greatly increases resistance to rust.

Special finishes are generally applied to screw products for either corrosion resistance, appearance or both. Such finishes are applied by one of the following methods: (1), coating the parts with a dissimilar metal as in cadmium plating; (2), the application of a mineral or organic substance as in lacquering; (3), the chemical surface conversion of iron or steel into basic phosphates as in Parkerizing; and (4), subjecting the parts to high temperatures in open furnaces as in bluing.

So called "commercial" plating usually affords ample protection for all practical purposes. However, for extreme conditions of weather, exposure to chemicals, etc., heavier deposits may be applied although it is extremely important to recognize the limitations of plating threaded or tapped parts. Excessive coatings which tend to build up on the crests and in the valleys will impair thread fit and may result in serious slow downs along production lines.

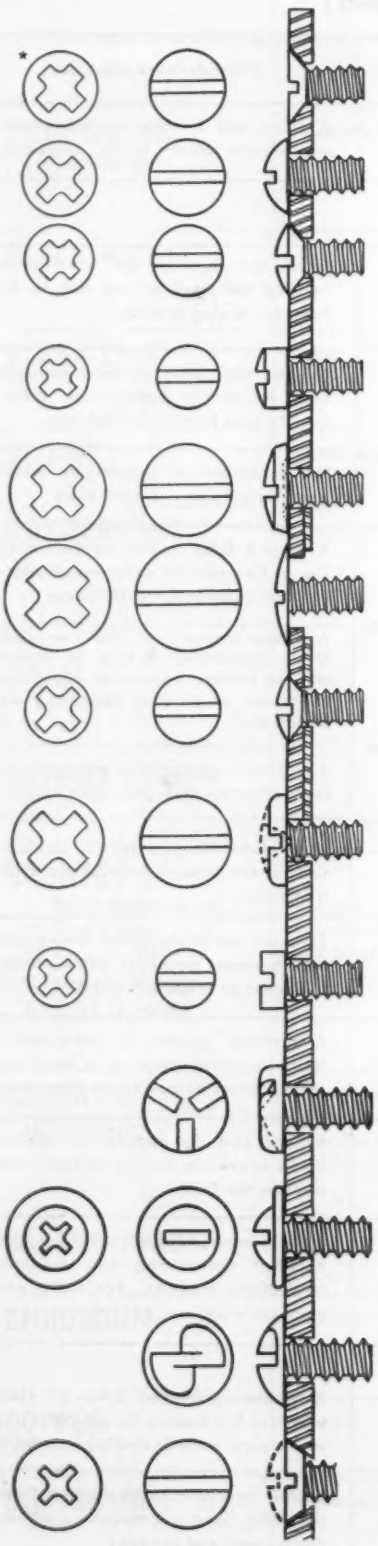
This chart of platings and finishes has been prepared to give you a quick, easy reference as to the type of finish that is most suitable for your particular product.

PLATINGS AND FINISHES (Continued)

FINISH	Color	Anti-Corrosion Properties	Suitability	Characteristics and Uses
EBONIZING	Jet Black	Slight	Carb. Steels Only	A clean and lustrous matching finish that will not soil the hands. Dielectric.
GALVANIZING: Electro	See "Zinc Plating"			
Hot Dip	Dull Gray	Excellent	Usually Steel	Good rust resistant but not recommended for small screws due to its tendency to clog threads.
GOLD	Gold	Excellent	All Metals	A highly decorative, corrosive resistant finish for special applications. Infrequently used because of high cost.
GRAPHITING	Dark Gray	Fair	Usually Steel	The application of graphite to metal parts for purposes of lubrication.
IRIDITE	Olive Drab Red Green Blue Black Bronze	Excellent	All Metals	A dipped finish usually applied over Zinc or Cadmium for purposes of coloring and additional rust resistance.
JAPANNING "BLEND-KOTE"	Various Colors	Excellent	All Metals	A lacquer enamel finish usually applied to a bonderized surface to match painted finishes. Applied to either the head only or all over depending on thread style.
LACQUERING	Transparent	Fair	All Metals	A protective coating used principally to cover other unstable decorative finishes.
LEAD Electro or Hot Dip	Dark Gray	Excellent	All Metals	A metal sheathing for specific applications where resistance to certain acids is required.
NICKEL	Silver	Excellent	All Metals	Excellent for applying to screws and nuts because of hard, stable finish. Dull white or bright burnished.
PARKERIZING	Dull Gray or Black	Excellent	Ferrous Metals	A chemical process of rust-proofing steel. Supplied plain as a base for paint or black oil stained for appearance.
PASSIVATING (Immunizing)	.....	.....	Stainless Steels	A nitric acid dip applied to Stainless Steels to remove foreign material and brighten the finish.
SILVER	Silver	Excellent	All Metals	An expensive, decorative finish with excellent rust-resisting and electrical conductivity qualities. For radio and electrical work.
TINNING Electro or Hot Dip	Silver Gray	Good	Principally Steel and Brass	A tin plating applied either by electrolysis or hot dipping for use especially where parts come in contact with food.
ZINC (Electro-Galvanizing)	Gray	Good	All Metals	Another commonly used, popular finish combining good rust-resisting qualities, appearance and economy.

Head Terminology

Many a puzzling fastening problem could be solved without resorting to costly special design if the theory and application of standard screw heads were more generally understood. So that you may become more familiar with this worthwhile and extremely valuable information, we have taken this information from Central Screw Company, Chicago, Illinois, on thirty of the most popular designs. Asterisks (*) indicates standard head styles.



***FLAT HEAD**
Supplied to standard dimensions with an 80° to 82° angle to be used where finished surfaces require a flush fastening unit, the countersunk portion offers good centering possibilities.

***ROUND HEAD**
The familiar head most universally used for general application. Good slot depth, ample underhead bearing surface and finished appearance are characteristic of this head.

***OVAL HEAD**
Fully specified as "oval countersunk", this head is identical to the standard flat head, but possesses, in addition, a rounded, neat appearing upper surface for attractiveness of design.

***FILLISTER HEAD**
The standard oval fillister head has a smaller diameter than the round head, but is higher with a corresponding deeper slot. The smaller diameter head increases the pressure applied on the smaller area and can be assembled close to flanges and raised surfaces. Headed in counterbored dies to insure concentricity, they may be used successfully in counterbored holes.

***BINDING HEAD (Straight Side)**
Most generally used in electrical and radio work because of its identifying undercut beneath the head, which binds and eliminates fraying of stranded wire. Offers an attractively designed, medium-low head with ordinarily sufficient bearing surface. Not ordinarily recommended as a Phillips Recessed head—see Pan Head for better functional design.

***TRUSS HEAD**
Also known as oven head, stove head, and oval binding head. A low, neat appearing, large diameter head having excellent design qualities, and as illustrated can be used to cover larger diameter clearance holes in sheet metal when additional play in assembly tolerance is required.

LENTIL HEAD
Designed with a greater degree of countersunk and low oval portion, this head also has a smaller than standard head diameter. Generally used on thin moulding strips requiring counterbored self-centering facilities and neatness of finished product. Similar styles also known as Jackson Head and Dunbar Head have smaller heads with standard 82° counterbore.

***PAN HEAD**
Sometimes called "Binder Head". Provides a low, large diameter head, but with characteristically high outer edges along the outer periphery of the head where driving action is most effective. Recommended for such items as self-tapping screws and designs requiring high tightening torques. Slightly different head contour when supplied with Phillips Recess. See dotted line.

FLAT FILLISTER HEAD
This head style was popular many years ago because it was easy to produce by milled-from-the-bar processes then in use. It has practically the same dimensions as a standard fillister head minus the oval section and is sometimes used in counterbored holes requiring flush finished surfaces. The use of the standard oval fillister shown above is recommended whenever possible.

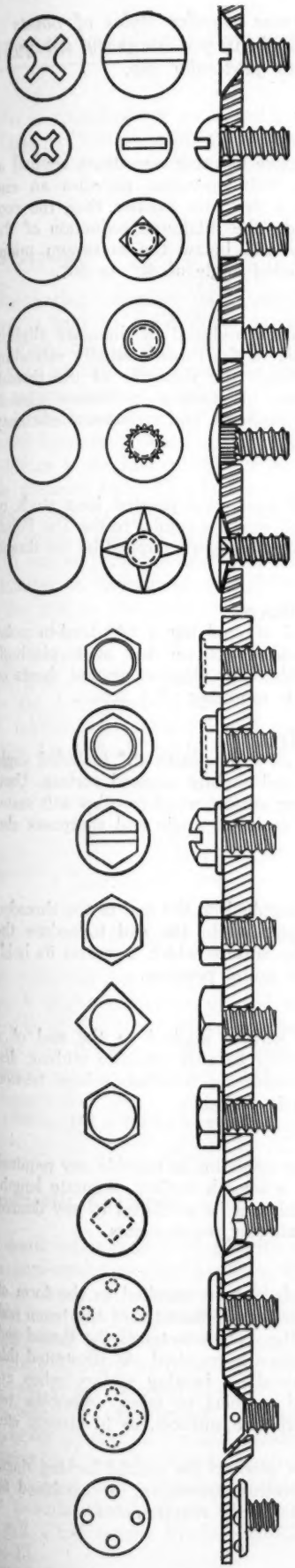
° *Most head styles also available as Clutch Recessed heads.*

HOLT HEAD (PATENTED)
Provides the perfect tamper-proof assembly. Theft-proof—decorative, yet inexpensive. Special drivers available for field removal or power driven assembly machines.

WASHER HEAD
This design has the finished appearance of a conventional round head plus washer, and was originally created to provide extra large bearing surface under the head. The modern "truss" head (carried in stock) normally answers his purpose. When a larger head diameter is required this washer head design is recommended.

ONE-WAY HEAD
This ingenious, tamper-proof type of head, once assembled cannot be removed, yet is driven with a standard screw driver. Manufactured with amazing economy in productive quantities, this design frequently solves costly assembly problems.

***FLAT AND OVAL HEADS (UNDERCUT)**
This is the standard flat or oval head 80° to 82° countersunk screw which has the lower one-third of the countersunk portion removed to facilitate production of extremely short lengths. As illustrated, it will fit a standard counterbored hole and is particularly adaptable to flush assemblies in thin stock.



FLAT HEAD (100° COUNTERSUNK)
This special flat head screw has been developed for applications requiring flush surfaces, and is recommended for use in soft materials, to distribute pressure over a larger and less angular surface. Very well adapted for use with thin aluminum, soft plastics, etc.

PLUMBERS HEAD
This head was developed many years ago for the plumbing trade. It offers a higher and slightly smaller diameter head than the standard round head to facilitate assembly and good solid tightening abilities. Modern designs recommend the use of the standard round heads.

SQUARE SHOULDER SCREWS
An adaptation of the standard carriage bolt design. Possesses a truss head on a square shank which resists rotation when located or driven into place. This square shoulder may also be staked into place as a permanent fastener. A great many varieties in all screw diameters are available in productive quantities.

ROUND SHOULDER SCREWS
This style is supplied with a regular truss head but possesses a round shoulder larger in diameter than the outside of the thread. Often used as a spacer between two sections or to provide bearing surface for rotating parts.

KNURLED SHOULDER SCREWS
A truss head on a round knurled shoulder make up the design of this part. It is used principally for locking purposes and may be molded into plastics or staked into metal. Shoulder length and knurled diameters can be varied to fit the application.

FIN HEAD BOLTS
A truss head supplied with either two or four fins to lock screw threads against rotation in thin sections of plywood, etc. More satisfactory than the square shoulder design for applications of this type because of the larger surface area contacted by the fins.

***INDENTED HEXAGON**
An inexpensive wrench head fastener made to standard hexagon head dimensions. The hex is completely cold upset in a counterbored die and possesses an identifying depression in the top surface of the head.

***INDENTED HEXAGON WASHER HEAD**
Produced in the same manner as the standard indented hexagon head but with a washer section at the base of the head to protect the finish of the assembly from wrench disfigurement.

***ACORN HEAD**
This wrench type head has been designed for appearance, speed of assembly, and protection against wrench disfigurement of finished surfaces. Its familiar domed "hex" atop the washer section locates quickly and easily with socket wrenches and can also be slotted for removal in the field.

***HEXAGON HEAD (TRIMMED)**
This is the standard type of wrench-applied hexagon head, characterized by clean, sharp corners trimmed to close tolerances. Recommended for general commercial applications, it is available in all standard patterns and in all thread diameters.

***SQUARE HEAD (TRIMMED)**
The standard commercial head as applied to machine bolts. This trimmed, accurately dimensioned head is also available in all diameters of screws, and offers square, sharp corners, generous bearing surface for wrench tightening.

HEXAGON HEAD (FINISHED)
This standard trimmed hexagon head screw has the added feature of a washer under the surface of the head slightly smaller in diameter than the distances across the flats which protects the finished assembly against disfigurement by the

SEATING BOLTS
This special combination of a countersunk square shoulder screw was developed for special applications requiring neat outside appearance combined with square shank locking features. Finishing washers may also be applied to this head to further enhance the appearance.

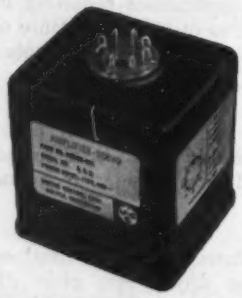
***HEAD STYLES (WELDING SCREWS)**
The welding screw has been developed to provide a strong, permanent threaded fastener which becomes an integral part of the assembly. It utilizes the principle or projection welding by means of multiple lugs applied to various head surfaces.

Type "U" (Underlug) for general application. Assemblies easily into pre-located holes and fully utilizes head strength. Top surfaces of head designed for efficient welding anode contact.

Flat Head styles take advantage of the self-centering feature of the countersunk portion and provide a smooth, flush outer surface.

***Type "T" (Overlug)** for applications requiring smooth, finished outer surfaces. Under surface of head is designed for perfect electrode contact.

Service-Seasoned Available Now



SOLID-STATE A-C SERVO AMPLIFIER

Designed specifically for use in 115 volt, 400 cycle systems, this United Control servo amplifier drives standard Size 11, 40-volt center-tapped servo motors. Its performance has been proved in service on a high-performance military aircraft, and it is qualified to applicable portions of MIL-E-005272B. Transients on power input leads up to 190 volts for 100 milliseconds will not damage the unit. Gain stability of ±2 db is maintained over an operating temperature range of −55°C to +102°C. Now in production, your requirements can be scheduled for early delivery. Firm prices reflect manufacturing efficiencies gained from experience.

CHARACTERISTICS

Input Impedance: 10,000 ohms
Voltage Gain: 1,200 min.
Power Consumption: 0.65 va to 5.5 va
Max. signal Input: 45 volts
Size: 2.06" x 1.81" x 2.25"
Weight: .63 lb. max.

Write for technical bulletin and prices.

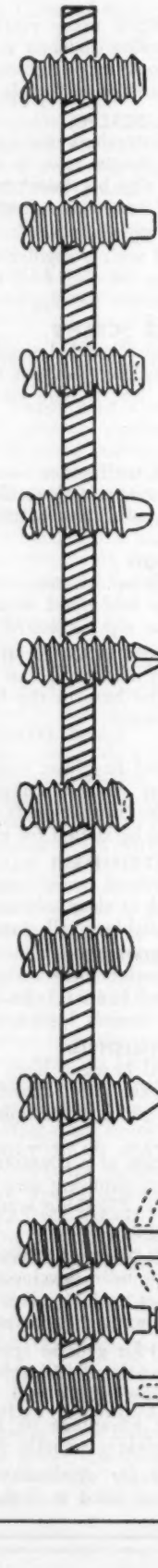
UNITED CONTROL CORPORATION

4540 Union Bay Place • Seattle 5, Wash.

CIRCLE NO. 41 ON INQUIRY CARD

POINT TERMINOLOGY

The chart below, illustrating the more popular styles of points available in theaded fasteners, will help you properly specify the most efficient fastening for your particular job.



DIE POINT
One of the least expensive pointing operations applied at the time of heading. This operation provides an end chamfer starting with a diameter smaller than the root diameter of the thread. The minimum reduction of the point is approximately 10% below the maximum minor diameter with an included angle of 40° to 50°.

DOG POINT
A straight pointed section reduced in diameter slightly below the root diameter of the thread, usually extending in length about two-thirds the diameter of the thread. Recommended for ease in starting, to insure against stripping fine threaded products, and to increase efficiency along production lines.

ROLLED POINT
An efficient method of producing pointed long studs or long screws with an end chamfer similar to the Die Point. The last thread and a half is slightly cupped by the thread roll-over operation.

PINCH POINT (ROUNDED)
An inexpensive method of applying a 60° lead-in point having a slightly rounded contour but with pinch-off marks on its surface. Used for aligning several sheets or assembling several parts requiring pilot action.

NAIL POINT (PINCHED)
Usually supplied with an approximate 45° included angle having a sharp point and slightly squared surface. Used for impinging or locking against wood or other soft material. Other degrees of included angle and sharpness also available.

CUPPED POINT
A special cup section supplied on the end of the threaded member having a depression in the end to reduce the area in contact with the surface which increases its holding and locking power under pressure.

ROUND POINT
A dome-like rounded surface applied to the end of a threaded member in order to offer pressure without disfigurement. Used for adjusting members where friction without cutting action is desirable.

CONE POINT
A precision cut-pointing operation to provide any required included angle. Offers a smooth surface, accurate length, and a sharp point which can be produced to any desired contour to fit your particular requirements.

CUT POINTS
A variety of tenon ends can be supplied in the form of straight cut points wherein the diameter of the tenon end is substantially below the root diameter of the thread and a square abutment surface is required. As illustrated this style of point offers excellent bearing surface when assembled into prepared washers or other assemblies requiring free turning pressure surfaces, as in clamps, etc.

Cut points can also be grooved for special locking rings, cupped for ease in riveting operations, or machined to other contours to meet specific requirements.

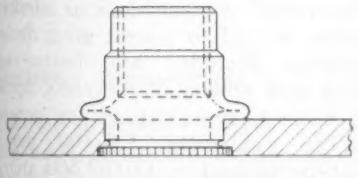
DESIGN TIME SAVER

NEW FASTENING DESIGNS

Here is a round-up of new fasteners and fastener literature that has been made available within the last 30 days.

Blind Locknut

Blind-mounting aircraft and missile locknut is said to have major advantages over blind-type fasteners and plate nuts for skin and structural sheet metal applications. Called the Davis Press Nut, the one-piece, self-locking threaded fastener is installed from the one side in a single drilled hole by a simple pressure tool. The locknut is a precision tubular part, threaded internally, with a small knurled collar or head at one end. An annular groove in the interior is machined out thinner than the rest so that when the nut is pulled under axial pressure for assembly it swages out on the reverse side to grip the sheet. Swaging action draws the head end of the nut forward, embedding the knurl and making the head flush with the metal.



Knurl gives the nut a high torque-out value. A slight undercut around the underside of the head provides space for flow of displaced metal without distortion. Standard Pressed Steel Co., Jenkintown, Pa.

Write No. 576 in Box on Inquiry Card

Steel-Plastic Fastener

Split head collar insert for plastics assures improved non-slip handles. The insert is made of stainless steel and molded into the plastic with threaded end extended. Molding of the insert to the plastic housing increases the holding power of the finished fastener. The stainless-plastic fastener is especially suitable for plastic knobs and handles. Fasteners are non-breakable, non-deforming, heat and corrosion resistant with threads that will neither seize nor gall. CSM Screw Prods. Co. Chicago, Ill.

Write No. 575 in Box on Inquiry Card

Self-Clinching Fasteners

Captive floating nut contained in fastener permits up to 1/32" adjustment for compensating slightly off center holes in mating attachment. Suitable for all materials with Rockwell hardness less than B-70 and sheet thicknesses from .040" up, the unit offers thread sizes from 4 to 10. Fastener can be clinched into metal sheets by any pneumatic or oil-hydraulic squeezing tool and are positively locked into place with high push-out and torque resistance. Penn Engr. & Mfg. Corp., Doylestown, Pa.

Write No. 461 in Box on Inquiry Card

Self-Locking Screws

Booklet entitled "One Piece Self Locking Screws and Bolts" explains the advantages of Holtite Nylok screws. One page is devoted to standards such as insert diameter, location, protrusion, torque, etc. The fastener employs a nylon insert in the threaded section to provide a smooth positive locking action. Continental Screw Co., New Bedford, Mass.

Write No. 574 in Box on Inquiry Card

Screw Threads

16 page booklet is a basic guide to screw thread technology. It briefly outlines the history of threads, defines the terminology used in the industry and explains with diagrams the differences between the major kinds of screw threads. Several pages of charts detail the measurements, characteristics and capabilities of the standard thread types. A torque guide outlines the normal load values that may be applied to bolts of various metals. H. M. Harper Co., Morton Grove, Ill.

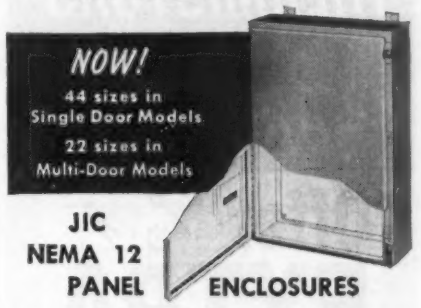
Write No. 607 in Box on Inquiry Card

Stud Welding

Design manual and stud specifications book contains data that applies to the use of a stud welding process, called Nelweld, an extremely fast and dependable method of end-welding fastener studs to steel or aluminum. Included in the design manual are data on physical properties of studs, methods of accommodating weld fillet, stud locating procedures and template design, welding power requirements, dimensions of portable and production units, standard stud types and design recommendations. Nelson Stud Welding, Lorain, Ohio.

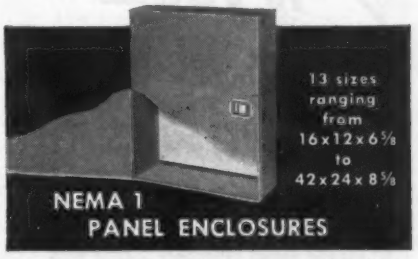
Write No. 608 in Box on Inquiry Card

WHAT'S NEW IN Hoffman ELECTRICAL ENCLOSURES?



JIC NEMA 12 PANEL ENCLOSURES

Completely oil-tight and dust-tight. Mounting panel is removable. Standard single door sizes now include many 8" and 10" deep enclosures to accommodate large circuit breakers and disconnect switches. Besides two-door models, we now offer three, four, and five door models up to 151½ feet long. Also available in NEMA Type 4.

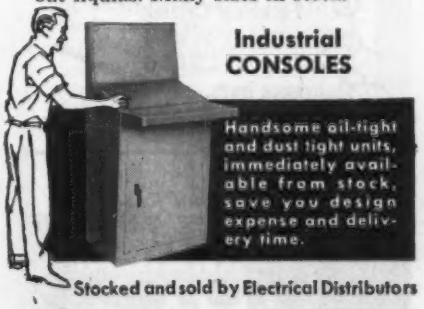


NEMA 1 PANEL ENCLOSURES

A control housing for locations that do not require the oil and dust-tight characteristics of HOFFMAN NEMA Type 12 enclosures. Removable mounting panel. Doors have lift-off hinges and plated "flush" latches.

Oil-tight time-saving LAY-IN WIREWAY

This new JIC Sectional Wireway (Patent Pending) offers the "lay-in" feature which simplifies installing wires from control point to equipment. Cover has full length hinge and is gasketed to seal out liquids. Many sizes in stock.



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36 page military components catalog is described as an invaluable manual on the latest military specifications covering fixed and adjustable power resistors, precision resistors, rheostats, tantalum capacitors and relays. The catalog is said to reduce the formidable maze of mil specs to a fundamental basis that simplifies the writing of "type designations" and the ordering of military components.

Source: Ohmite Mfg. Co.
Skokie, Illinois

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Infrared Detectors

Detailed description of infrared radiation detectors that are uniformly sensitive throughout the entire visible, near-infrared and far-infrared spectrum is presented in a bulletin. With diagrams, curves and useful formulas, the bulletin describes static and dynamic characteristics of thermistor bolometers and also covers various types of window materials. One section covers circuit design considerations.

Source: Servo Corp. of America
Hicksville, N.Y.

For your copy: Write No. 596 on Inquiry Card

Resins For Rubber Compounding

16 page booklet presents the latest data on the properties and functions of resins for use in compounding rubber and in formulating rubber-based adhesives. Resins include the major types of phenolics (thermosetting, novolac, heat-reactive alkyl and non-heat-reactive alkyl), terpene-phenol resins and pure hydrocarbon polyterpenes. Use of these resins with butyl, natural, neoprene, nitrile, reclaimed and SBR elastomers is discussed.

Source: Schenectady Varnish Co., Inc.
Schenectady 1, N.Y.

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Sampling Oscillography

Sampling oscillography is a method for pulse analysis of ultra fast circuits. Application note traces the history of the sampling technique and its recent application to oscilloscopes, extending their usefulness into a higher portion of the frequency spectrum. It also discusses general sampling considerations and describes the design and operation of a sampling oscilloscope.

Source: Hewlett-Packard Co.
Palo Alto, Cal.

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Electronic Switch

24 page brochure covers theory of operation, circuit design information, characteristic curves and the many applications of the Beam-X switch in the fields of counting, coding, distributing, converting, multiplexing, switching and sampling.

Source: Burroughs Corp.
Plainfield, N.J.

For your copy: Write No. 595 on Inquiry Card

Vibration Control

Eight page comprehensive guide to resilient mountings and mounting systems for vibration, shock and noise control. Design, application and performance data are given as an aid to the selection of the right bonded rubber mounting or flexible mounting system for any particular job.

Source: Lord Mfg. Co.
Erie, Penna.

For your copy: Write No. 604 on Inquiry Card

DC Contactors and Relays

32 page catalog covers contactors and relays for all dc industrial control. Standard frame-and-coil assemblies and a "universal" contact block or interlock element is said to permit great design flexibility. Included are illustrations, layout and schematic diagrams, application data, specifications for general purpose contactors (25-100 amp), mill-type contactors (100-2,500 amp), time delay contactors, general purpose and timing relays, instantaneous-overload and thermal-overload relays, field-loss relays, field accelerating and decelerating relays and high drop-out relays.

Source: General Electric
Schenectady, N.Y.

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Clutches and Differentials

48 page pocket-size catalog presents data on a complete line of magnetic clutches and precision differentials. The magnetic clutches meet stringent Mil-E requirements with ambient temperatures of 125 C, vibration through 2000 cycles, noise, extreme shock and high reliability of operation under combinations of conditions. The mechanical differentials meet Mil-E-5272C.

Source: Sterling Precision Corp.
Instrument Division
Port Washington, L.I., N.Y.

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WORTH FILING

Shaft Position Encoders

12 page brochure gives complete specifications for 13-bit, 8-bit, and incremental encoders. In addition, operating principles of a new type of magnetic readout is described in detail with illustrations. Recommended simplified transistor circuitry is given for interrogation playback, detection and amplification of the encoders. A conversion table of binary code to decimal or Gray codes is included.

Source: ASCOP, Div. of Electro-Mech. Research, Inc., Princeton, N.J.
For your copy: Write No. 503 on Inquiry Card

Fluid Systems

140 page catalog on industrial fluid systems provides complete dimensional and functional data on all types of hoses, fittings, adapters and self-sealing couplings. All specifications, such as pressures, temperatures, bend radii, etc., are included.

Source: Aeroquip Corp. Jackson, Mich.
For your copy: Write No. 538 on Inquiry Card

Electronic Components

288-page electronic products catalog is tron tubes, electronic instruments, industrial systems and microwave instruments. Types of components and systems include photomultiplier tubes, klystrons and cavities, secondary emitters, travelling wave tubes, oscilloscopes, analogue computers, tape decks, stroboscopes, transducers, balancing machines, closed-loop TV systems, power supplies, signal generators, attenuators, and many others.

For your copy:
Write on your company letterhead to:
Hoffman Electron Tube Corp.,
804 Newbridge Ave., Westbury, L.I., N.Y.

Springs

20 page catalog, listing over 750 springs, is said to help eliminate time-consuming calculations. Types include compression, extension and instrument made of music wire and stainless steel. Units meet mil specs.

Source: Lee Spring Co., Div. of Leetronics 30 Main Street, Brooklyn, N.Y.
For your copy: Write No. 331 on Inquiry Card

Timing and Control Devices

30 page reference for automation components and control systems covers timing components and linear measuring systems for industrial and military use. Standard timers and counters are reviewed and specs and characteristics are listed. Also included are differential transformers, motion transmitters, edge guide, pressure transmitters, demodulators, indicators and recorders. Control relays, servo mechanisms, amplifiers and servo kits are also described.

Source: Automatic Timing & Controls, Inc. King of Prussia, Penna.
For your copy: Write No. 563 on Inquiry Card

Gears

128 page master catalog lists over 50,000 components. Section lists miniature, precision gears cut to center distance. By holding this center distance to nominal, a backlash of 0.0002 to 0.0008 intermated eliminates possibility of binding. Also included are differentials, speed reducers, gearheads and design kits available for experimental needs.

Source: Dynamic Gear Co., Inc. Amityville, N.Y.
For your copy: Write No. 565 on Inquiry Card

Capacitors

20 page booklet covers general purpose disc and tubular ceramic capacitors. Included are detailed specs on temperature compensating, temperature stable and semi-stable, bypass, high and low voltage types as well as resistor-capacitor combinations. General technical data includes temperature compensating curves, tolerance charts and color code tables.

Source: Centralab, Milwaukee, Wis.
For your copy: Write No. 562 on Inquiry Card

Silicon Rectifier

42 page silicon rectifier handbook provides specification data on more than 80 separate rectifier units with range of 50 to 600 volts PIV and ½ through 400 amperes. Includes technical data on selection and application factors.

Source: Standard Rectifier Corp. Santa Ana, Calif.
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The Inventing Process

Inducing the Spark, Part II

In the previous section of this column, January 1960 issue, we pointed out that psychologists have divided the inventing process into four stages:

Preparation, Incubation, Illumination, Verification and Elaboration.

Usually when the mind starts to solve an invention problem, it picks idea elements or patterns already on hand, generally those that are most familiar. But more often than not, the first pattern picked is the wrong one, and the more ideas are organized around this incorrect pattern, the more difficult it is to break away from.

Breaking through this barrier may be accomplished in one of four ways:

- By the impact of an accident.
- By becoming convinced from long frustration that the pattern being used is the wrong one.
- By following one line of thought around a circle until headed in the opposite direction.
- By temporarily abandoning the quest and resuming it after the old approach has been forgotten.

Impact of an accident has been responsible for shifting inventors' lines of thinking to new and correct patterns in many cases. Most familiar are the classic examples of Goodyear's accidental invention of the vulcanization of rubber when some rubber and sulphur were dropped on a hot stove, and Perkin's discovery of how to make aniline dyes when he added alcohol to a mass of coal tar. The reader who is interested will find many other instances in standard lists of accidental inventions (see Anonymous, Accidental Discoveries, Mechanical Engineering, 1926, No. 1948, pp. 865-866) and particularly in Rossman's treatment of accidental invention (see Rossman, J., Psychology of the Inventor, Chapter VII).

Einstein's origination of the relativity theory is a classic case of a scientist becoming convinced, after long failure to fit idea elements to a familiar pattern, that he is using the wrong pattern. It took him seven years to give up the long established idea pattern of classical physics that space and time are constants and the velocity of light is a variable, for the idea pattern that light velocity is a constant and space and time are variable depending on the position of the observer. Because the first idea pattern had the prestige of a body of knowledge built up over centuries, it took a great imagination to question and then abandon it. (see Wertheimer, Max, Productive Thinking. Harper, New York, 1945; also Platt, W., and Baker, R. A., Relation of Scientific Hunch to Research. Journal of Chemical Education, Vol. 8, 1931, pp. 1969-2002).

A good example of following one line of reasoning around a circle till it heads in the opposite direction is afforded by the example, given in Rossman, of the invention of a can soldering machine (Rossman, J., Psychology of the Inventor. Figures 1-13, page 65). The inventor was convinced, at the start, that he couldn't bend the surface of a solder bath upward to meet the ends of the can, so he reasoned that solder in wire or bars, applied to the can with a soldering iron, would have to be used. But when he had followed out this approach about midway to its logical conclusion he found it led to a way of lifting up the surface of a solder bath (by capillary attraction) to meet the end of the can being soldered.

Probably the most common procedure of inventors in overcoming the barrier to the illumination stage is to temporarily abandon work on the problem. During that interval the earlier line of approach frequently dies out, and on reattacking the problem the mind takes a new and often the correct approach or pattern. This is not a positive procedure but the one most commonly described. Probably the most famous and universally cited case is Poincare's invention of Fuchsian functions (Poincare, H. Foundations of Science. The Science Press, New York, 1913, pp. 387-388). For the industrial inventor, however, the following instance (quoted from G. A. Abbott. See Platt and Baker, cited above, p. 1977) will be of greater interest:

"While a graduate student at Tech I was engaged in the study of the problem of determining the successive ionization constants of ortho-and pyro-phosphoric acids. A very promising method (at that time direct ph measurements were not made) was the direct measurement of the hydrolisis of the ammonium salts of these successive acids. This was attempted by shaking the hydrolized solution with an immiscible solvent which would dissolve ammonia. Chloroform was found to be suitable, and the attempt was made to measure the partition coefficient of ammonia between water and chloroform. Upon shaking the ammonia solution with the chloroform, emulsions of water in chloroform were obtained which completely vitiated the method.

"After intense concentration and many vain attempts to overcome this difficulty, I reluctantly decided to abandon this method. . . . I decided to. . . . completely forget my work. . . . Freeing my mind of all thought of the problem I walked briskly. . . . when suddenly. . . . an idea popped into my head. . . . as if a voice had shouted it in these words: In pharmacy and in industry, we clarify emulsion by means of a high speed centrifuge; such a method would be impractical in a thermostat. But if rapid whirling for a brief time will do it, why will not slow rotation for a longer time accomplish the same results?

". . . . I returned to the laboratory, placed three liter bottles of the materials on the stirrer of the bath in such a way that the solutions were rotated, bringing alternate layers of water and chloroform in contact with the walls of the bottles. I then went to lunch. . . . Upon my return more than an hour later I was delighted to find that the two phases had separated perfectly. The method was applied with success and soon led to a definite solution of my problem. . . ."

FOLLOW THROUGH

The chain reaction of "illumination" does not end merely with a glow of satisfaction and an exclamation of "Eureka!" It triggers two other chain-reactions: One is a chain of ideas visualizing experiments or devices that will verify

the soundness of the "flash" solution. The other is a train of thought for further applications of the invention implied by the solution.

For example, consider Mendeleef's abstract but very useful invention—the Periodic Table of chemical elements. He conceived the idea of arranging all the elements in the order of increasing atomic weight on a grid or checkerboard so that all those of like chemical properties fell in one column. This table had some gaps, which implied that there were unknown elements that would fit into the unfilled spaces in the table. In addition, the position of these blanks in the table implied what the properties and characteristics of these elements would be. Verification of Mendeleef's concept, therefore, called for conceiving experiments for discovering and identifying these missing elements. That is exactly what not only Mendeleef but a host of chemists and physicists ever since Mendeleef's day have been endeavoring to do. And only recently, with the evolution of nuclear physics and transmutation of the elements, have we completely filled the table, thereby fulfilling the implications of Mendeleef's concept and verifying the concept itself.

A striking description of the entire four-stage procedure of inventing, as applied over and over again in the field of crystallography, is contained in the following account condensed from an article by Sir. Laurence Bragg, who is himself eminent for creativity in that field (see Bragg, Sir Lawrence, Recent Advances in the Study of Crystalline State. Science, Oct. 29, 1948, Vol. 108, No. 2809, 455-463).

In 1912, Laue made the suggestion that the regularly-placed atoms in a crystal would act as a diffraction grating for X-rays. Therefore, projecting a beam of X-rays through a thin layer of crystalline material onto a photographic plate would cause the plate to show a "diffraction pattern" of regularly arranged spots resulting from the reflection of the X-rays by the regular arrangement of atoms in the crystal. Obviously these patterns of spots could be interpreted to reveal the architecture of atom arrangement in the crystal.

For many simple crystals this process is easy, but for complex molecules having a variety of different atoms in intricate arrangement it is very difficult and complex. "Hidden in the pattern of diffracted spots lies all the information required to establish the structure, if only one can find the 'open sesame' which would reveal the treasure."

So difficult is this problem that ". . . . No way has yet been found of arriving . . . at a solution by a mathematical treatment. . . ." So only one thing remains—invent a structure (atomic arrangement) to fit the diffraction pattern obtained for each crystal.

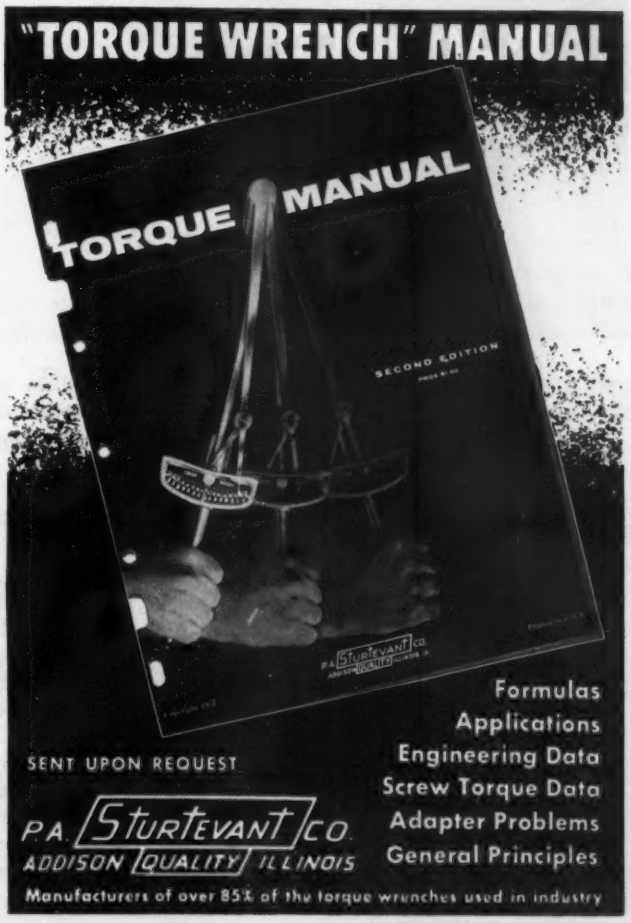
"How is it done? The analyst has before him the separate bits of a jig-saw puzzle, each one of them being a periodic element in the structure, and he has to fit them together so that they build up a picture which makes sense, meaning by this a distribution of scattering matter corresponding to the atoms which he knows to be there."

To solve this jig-saw puzzle ". . . the crystallographer has to fall back on a process of trial and error. In effect, he has to guess a likely structure, calculate how it would diffract, and compare with observation. If there is no correspondence, a fresh guess has to be made. In making guesses at possible arrangements, he draws on a wealth of experience of the way atoms associate together in space, obtained from previous analyses. He pushes the atoms this way and that, remembering, as he does so, the many other alleys he has previously explored which have proved to be blind. . . . Finally, after six months or longer, and if he is fortunate, everything clicks into place. An arrangement is found that fits so well to the most important observations that it is clear he is on the right track at last. Once the general scheme is discovered, the final adjustments are relatively easy, and one more example is added to the growing list of known structures."

And immediately in the wake of this "flash" solution comes the verification that it is correct. ". . . Again there is a curious characteristic of this crystal work: We can be sure of our results. Further refinement may be made later, but the evidence that our guess is right in the main is quite overwhelming and certain."

The "flash" also brings on immediately a whole chain of thoughts on further applications implied by the solution. ". . . . the successful analysis of one structure often leads to quite a new understanding of a whole range of forms of matter. The structure of diopside, for example, marked the turning point in understanding the nature of all silicates; the structure of one polyacid shows how they are all built up; the structure of a few simple salts led Pauling to formulate the rules which determine the structure of inorganic compounds in general." Or, as he so aptly puts the whole business of verification and elaboration a little further on, ". . . . the solution seems so obviously right once it has been found, and explains so much."

The above discussions may help in cultivating our inventive abilities. But the greatest help to the growth of this ability is to study the techniques exemplified in the work of outstanding inventors, and to practice the application of these techniques in actual problems. The remainder of this series of columns will be devoted to pointing out such techniques and to providing exercises for their application.



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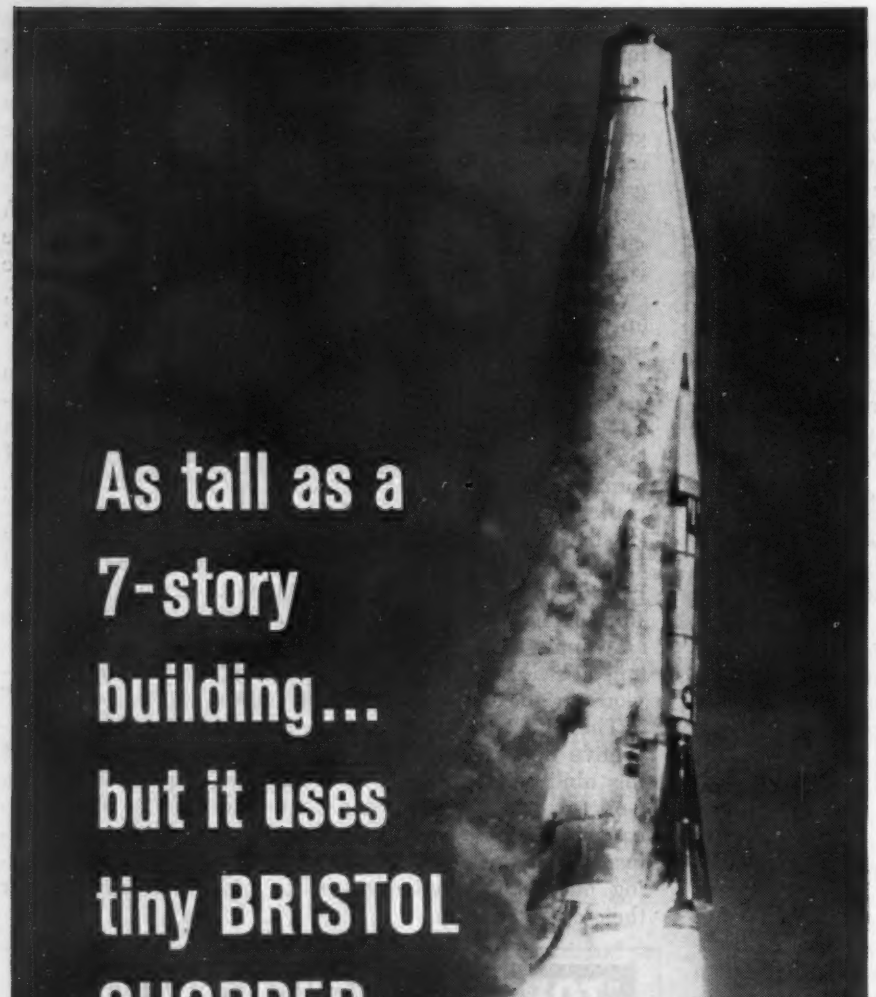

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Source: National Tel-Tronics Corp.
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Components Testing

Guide is available to aid the design engineer in choosing the right test and sensing component. Chart contains complete specs on panel lights, switches, fuseholders, test prods and jacks and molding materials. Guide can be tucked into vest pocket or hung on a wall for ready reference.

Source: Alden Products Co.,
Brockton, Mass.
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Connectors

52 page catalog describes a complete line of plug and receptacle connectors with crimp-type snap-lock contacts. A selector chart details many significant characteristics. Technical discussion of plating types with specific applications, along with a discussion of installation tooling, its functions, features and characteristics are included. Miniature rectangular, rack and panel, coax and miniature coax, modular, general purpose, printed circuit-edge-type and pin-type and other connectors are covered.

Source: Burndy Corp.,
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WORTH BUYING

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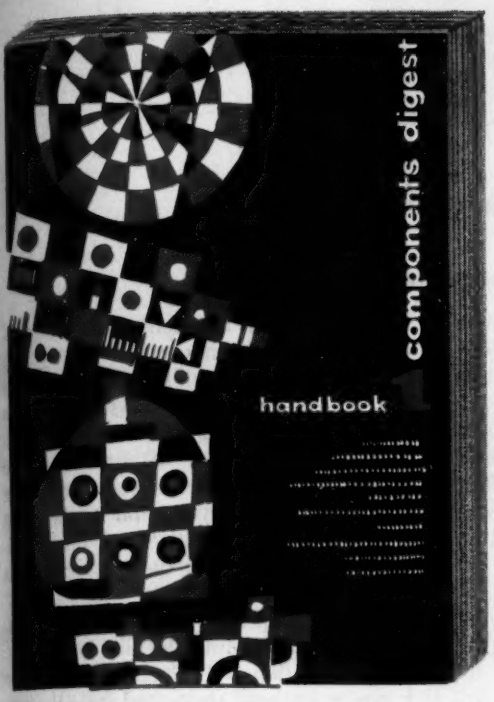

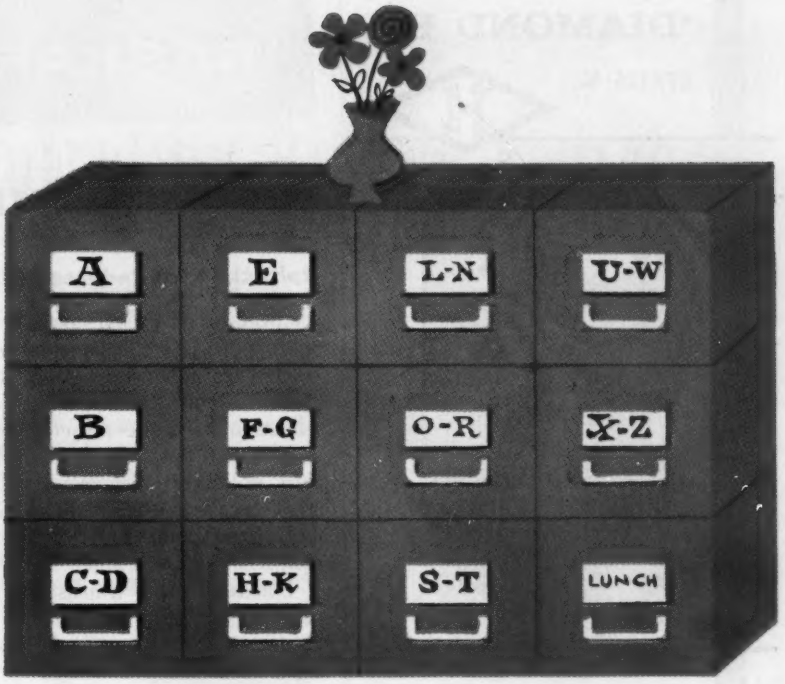

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RESEARCH

DIFFUSED BASE TRANSISTORS

Epitaxial Film Reduces Switching Time

Combining diffused base technology with epitaxial film techniques is expected to have far reaching implications in both the fabrication and application of semiconductor devices.

Major reductions in switching time and collector resistances of diffused base transistors have been realized at Bell Telephone Labs by the use of epitaxially grown films.

Diffused base transistors require a relatively high resistivity collector region in order to attain low capacitance and high voltage breakdown. Typically, to afford ease of mechanical handling, this region has been much thicker than required electrically. The excess width increases the collector resistance and, through carrier storage, the switching time.

Ideally, the width of the lightly doped collector region should be in the neighborhood of 0.1 mil, which is about a factor of 30 narrower than normally used. Semiconductor wafers prepared by conventional methods become extremely difficult, if not impossible, to handle as they approach this desired width.

Bell Telephone Labs solved the problem by using epitaxial film techniques. Lightly doped epitaxial films were grown on and supported by a low resistivity substrate giving the desired combination of electrical properties and mechanical strength. The term

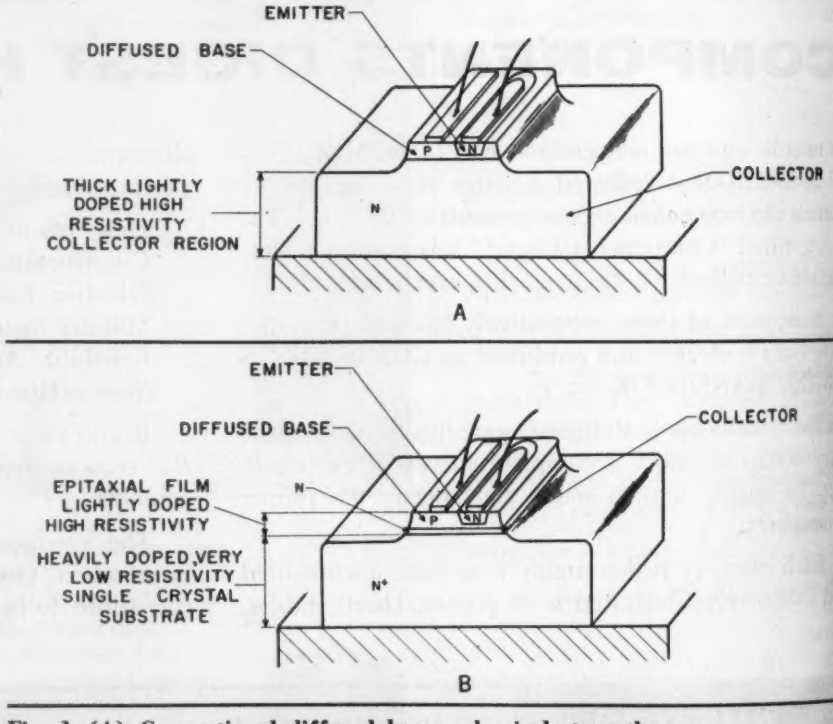


Fig. 1 (A) Conventional diffused base transistor in which the excess width of the collector region, necessary for mechanical strength, is formed of lightly doped, high resistivity material, increasing the collector resistance and, through increased charge storage, the switching time. (B) Epitaxial diffused transistor construction. Here the width of the lightly doped collector region has been minimized by using an epitaxial film grown on and supported by a heavily doped, low resistivity substrate. This structure gives the desired reduction in both series resistance and switching time while maintaining mechanical strength.

New technique involves modification of the starting material and can be introduced directly into the front end of the existing diffused base production facilities without any further changes. Single crystal wafers of heavily doped material are first cut and polished. A lightly doped thin film (about 0.1 mil) of the same conductivity type is then deposited epitaxially on the wafer surface. This film provides the desired thin, lightly doped collector region. From this point on, standard diffused base techniques are employed.

"epitaxial" means that the film is a direct extension of the single crystal structure of the substrate wafer.

Diffused base transistors have been made at Bell Telephone Labs on epitaxial layers of both germanium and silicon and have exhibited the theoretically predicted improvements. For example, in two similar silicon transistor structures, one conventional and the other using the epitaxial material, switching time in a typical circuit has been reduced from 200 to 20 milliseconds. Collector series resistance of the epitaxial transistors was reduced by a factor of more than 10, comparable to that of conventional devices 15 times larger.

In addition to improvements in switching time and collector resistance, the new technique simplifies the design and understanding of transistor devices and brings them closer to ideal forms, such as n-p-i-n structures. The addition of the epitaxial film technique to the well established diffusion technology provides an extra degree of design freedom which should result in new devices previously difficult or impossible to achieve.

WORTH FILING

Digital Circuits

Brochure entitled "Transistor Digital Circuits" describes advanced solid state transistor and magnetic components. Among the units described are card and modular circuits, shift registers, gates, amplifiers, oscillators, pulse shapers, delay multivibrators and flip-flops.

For your copy write on company letterhead to:
Components Div., Epsco, Inc.
275 Mass. Ave.
Cambridge, Mass.

Air and Vacuum Pumps

32 page catalog describes rotary positive air pressure and high vacuum pumps, gas boosters and air motors. Included are details of construction, dimensions, capacities, performance curves on all pumps plus comprehensive engineering and application data.

Source: Leiman Bros., Inc.,
Newark, N.J.

For your copy: Write No. 311 on Inquiry Card

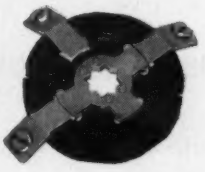
DESIGN NOTES on

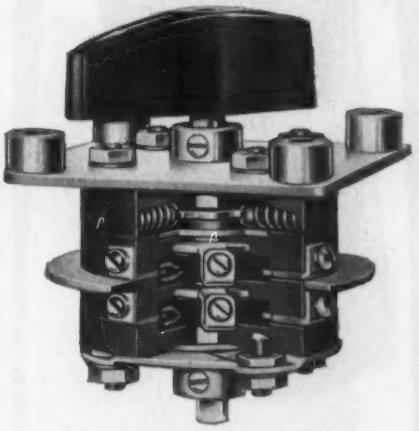
Control by Rotary Switches

No. 2 of a series

Rotary-switch Contact Structures

An important difference between the rotating-blade switch and the cam-operated switch is the way contacts are made and broken. In the rotary switch, a *wiping contact* is provided. The movable contact wipes across the full width of the stationary contact(s), clearing away dirt or corrosion as the switch is operated and keeping the contact area clean so as to minimize contact resistance and consequent heating. In some types of light-duty switches, the wiping action occurs at one side of each contact. For switches that must handle moderate or heavy currents (5 amperes to 200 amperes), the wiping action usually occurs on both surfaces of one contact (usually the stationary contact) and on the inner faces of the double-blade contact that mates with it.





Cutaway view of Type JR Switch showing positive detent mechanism.

Rotary-switch Drive Mechanisms

Two general types of drive mechanism are used with rotary switches. They are the direct drive with detent and the snap-acting type. The direct drive is generally used with light-duty switches or with switches having more than eight stationary contact positions. The detent action holds the movable contact in alignment with a stationary contact by spring loading. This is often accomplished by having the stationary contact slightly below the surface of the insulating deck and depending on the resilience of the movable contact to hold the contacts in line. While this construction is often adequate for light-duty switches, a more positive detent action is required where maximum life, reliability, and stability are necessary. Such action is provided by a separate detent mechanism in which the detent springs are not part of the electric circuit and the position of the contact-carrying rotor is established by a star wheel that engages spring-loaded balls or rollers.

With the direct drive, the speed of contact opening or closing depends on the way the operator turns the switch handle. In direct-current circuits, it is desirable to make and break contact quickly. One way to accomplish this is by using a snap-acting drive mechanism. Turning the switch handle winds a spring and, when enough energy has been stored up, the spring snaps the movable contact quickly into the next position. Because of the mechanics involved, this action is generally provided only for four-position switches although it can, under some circumstances, be furnished with eight-position switches.

Rotary-switch Circuit Possibilities

One of the most important advantages of the rotary switch is its adaptability to control of complex circuits. This aspect of design will be discussed in the next advertisement in this series.

ESCO Bulletin No. 8A, containing useful information on the construction and application of rotary switches, as well as examples of ESCO switches that utilize the design principles discussed in these advertisements, will be sent you on request.

ESCO of WEYMOUTH
ELECTRO SWITCH CORP.
Weymouth (Boston 88), Massachusetts

CIRCLE NO. 50 ON INQUIRY CARD

NEW SERIES of Antenna SLIP RING Assemblies

12 to 500 RINGS

A standardized line of large Slip Ring assemblies, designed for a multiplicity of instrumentation, control and power circuit applications. First production assemblies are in use on radio telescopes, radar and tracking antennas and human centrifuge installations.

Assemblies vary from 12" to 72" in length, are either shaft or flange ball-bearing mounted and may be specified with hermetically sealed housings. Noise levels are held to a minimum. So are intercircuit losses, cross-talk and radiation, through proper shielding.

For complete information, write:

SLIP RING COMPANY of AMERICA

3612 West Jefferson Blvd., Los Angeles 16, Calif.

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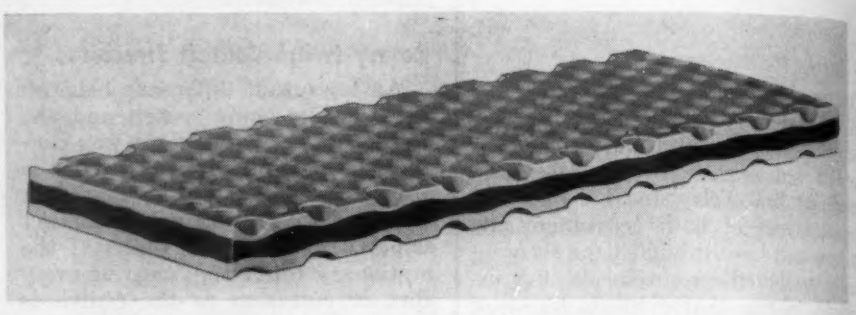


Fig. 1 Machinery mounted on pads of Vibra-Check cannot creep or crawl because of the high coefficient of friction of the material and the vacuum suction cup design molded into the parallel upper and lower contacting surfaces. Leveling problems are minimized since no extruded elevations exist.

VIBRATION ISOLATION

Anti-Vibration Material Simplifies Installation and Relocation of Machines

Placing pads of an anti-vibration material called Vibra Check under the base or feet of heavy rotary or reciprocating machinery prevents any creeping or crawling of the equipment, thus avoiding any need for bolting or lagging it to the floor. The manufacturer, Lowell Industries, Inc., of Boston, Mass. say this new material will isolate from 40% to 90% of vibrations in the frequency range from 30 to 100 cps.

In applications involving light unit loadings, such as for small business machines and delicate instruments, bolting down the equipment is recommended to increase the loading on the mounting pad for efficient vibration isolation.

Vibra-Check is a synthetic material composed of two layers of tough vinyl chloride elastomeric resin bonded to both sides of a strong reinforcing core of monofilament fiberglas. These components are fused under heat and high pressure to form a unit of three layers with three different natural frequencies which isolate and absorb a wide range of vibrational modes. It is resistant to moisture, oils, greases, detergents, brine, solvents, and many other chemicals. Therefore, it is easy to keep clean and will not deteriorate. Under high shock load, it shows no deformation or permanent set. Its high breaking point of 7500 psi, its dimensional stability and high-impact flexural and tensile strength insure its re-usability. The new material also has the advantage of economy. Costs of original installations are comparatively small. In addition, subsequent relocation of machinery is greatly simplified and made most favorable dollar-wise since Vibra-Check can be used over again. To relocate a machine it is only necessary to jack up the base, remove the pads and relocate them and the machine in the new position. Vibra-Check is available in sheets 22" x 23", or it can be furnished cut to sizes suitable for base and feet of any machine so as to yield a unit loading of 50 to 100 psi, the area of its greatest vibration-absorptive efficiency.

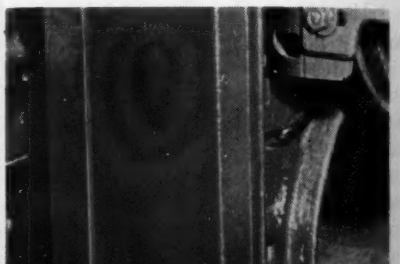


Fig. 2 Vibra-Check can be successfully installed to reduce vibration resulting from operation of any type of machine tool, textile machine, or other rotary or reciprocating impact-producing machinery.

Write No. 557 in Box on Inquiry Card

NEW PIEZOELECTRIC COMPOUNDS

Electromechanical Coupling Coefficient Four Times that of Quartz

The discovery that zinc oxide and cadmium sulfide are strongly piezoelectric has just been revealed by A. R. Hutson of Bell Telephone Labs.

Dr. Hutson decided to investigate the piezoelectric constants of these materials while studying some of their unusual conductivity properties, especially the large magnitude and temperature dependence of the phonondrag effect observed in thermoelectric power measurements. A large piezoelectric constant seemed to explain these anomolies theoretically, but had never been observed experimentally.

Both zinc oxide and cadmium sulfide have long been recognized as n-type semiconductors. Zinc oxide usually shows a room temperature resistivity less than 10^3 ohm-cm which effectively shorts out all experimental evidence of peizoelectricity.

The conductivity of the zinc oxide was "quenched' by diffusing lithium atoms into the material, to act as acceptors for the excess electrons which were contributing to the conductivity. When this was done, the resistivity of the material was raised from 10^3 to 10^{12} ohm-cm at room temperature.

Resonance - anti - resonance measurements and direct squeeze measurements were made on vapor-phase grown needles and flux-grown platelets of zinc oxide and on the vapor-phase grown cadmium sulfide. With dielectric constants of 8.2 and 9 for ZnO and CdS respectively, electromechanical coupling coefficients were calculated to be approximately 0.4 for ZnO and 0.2 for CdS, compared with 0.095 for quartz.

WORTH FILING

Microwave Antennas

16-page catalog provides detailed engineering data on 60 antennas covering all current commercial and military microwave frequency ranges. Selected cables, waveguides and anti-icing devices are also listed.

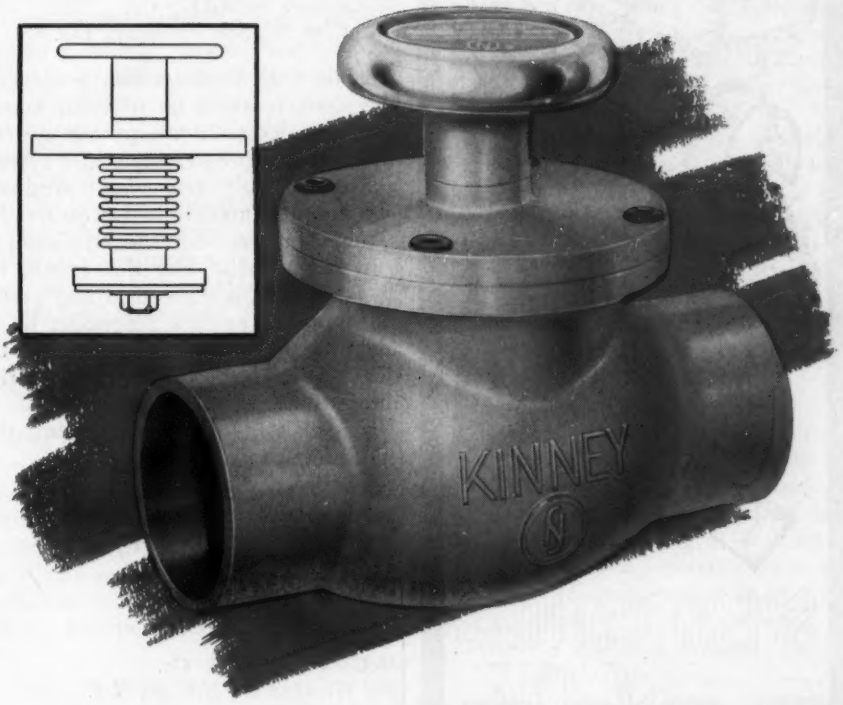
Source: Andrew Corporation, Chicago, Illinois

For Your Copy: Write No. 431 on Inquiry Card

Kinney®

BBSM VACUUM VALVES

say, "STOP" and "GO" and Mean It!



The new Series BBSM KINNEY Vacuum Valves form a reliable force of "Traffic Cops" for your Vacuum systems. In sizes 1", 1½", 2" and 3", these Bronze Bellows Sweat Fitted Valves are especially designed for Vacuum applications having soldered or brazed manifolding. They are of the globe type with non-rising stem, with positive isolation of rotating parts. The brass bellows is sealed to the seat disc and bonnet flange by static "O" rings of Buna N.

Assembly of KINNEY BBSM Valves into the Vacuum system is supremely simple. Removal of stem, cover and bellows assembly as a unit from the body of the Valve is accomplished by unscrewing four cap screws – thus replacement of bellows is no problem. Each KINNEY BBSM Valve is mass spectrometer leak tested to assure vacuum tightness.

KINNEY VACUUM DIVISION
THE NEW YORK AIR BRAKE COMPANY
3521H WASHINGTON STREET • BOSTON 30 • MASS.

WRITE FOR CATALOG BULLETIN NO. 3421.1A TODAY!

Please send me Bulletins 3421.1A and 3421.3 giving full information and prices on KINNEY BBSM Vacuum Valves.

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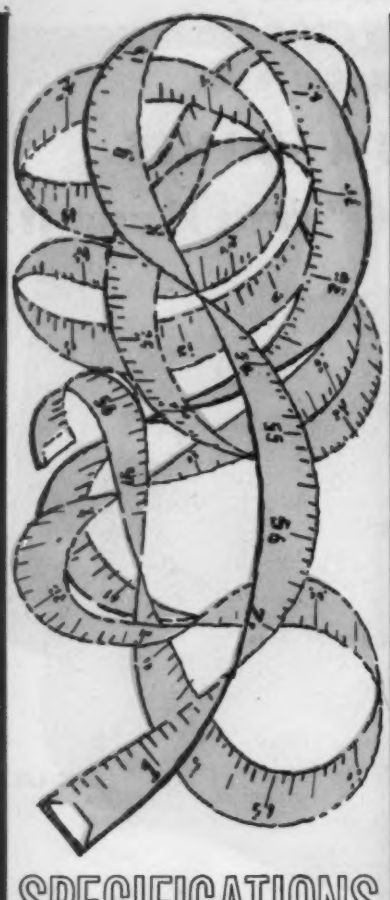
CIRCLE NO. 52 ON INQUIRY CARD



SPECIFICATIONS BY THE YARD!

1000 + with over 1000 standard solenoid designs to choose from, and the largest engineering staff in this field . . . PSP can quote highly critical specifications literally by the yard.

State your problem: PSP engineers will select or modify standard models, and custom engineer units to solve your specific system or component problem.

Environmental, qualification, and production testing laboratory . . . parts fabrication shops . . . complete within PSP's facility—provide unequalled flexibility to meet stringent requirements.

SOLENOIDS AVAILABLE: DC Linear; 6 to 300 VDC, and AC 400 CPS Rectified Types to 4" diameter • Sub-Miniature Types • High Temperature Types to 1000°F • Cryogenic Types to —400°F • Pressurized Types to 10,000 psi • **DC Rotary Solenoids,** 6 to 300 VDC, sizes ¾" and larger; 0° to 60°, CW or CCW rotation. • Intermittent or continuous duty models, to MIL-S-4040C, MIL-E-5272 and MIL-E-5400 • Mounting and electrical connections to requirement • Other PSP products: Miniature Solenoid Operated Pneumatic Valves • Solenoid-Switch Assemblies.

Write for detailed information on specific requirements.

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CIRCLE NO. 54 ON INQUIRY CARD

BOOK REVIEWS

Automatic Data Processing Systems

Robert H. Gregory and Richard L. Van Horn
705 pages, $8.75
Wadsworth Publishing Co.
431 Clay St., San Francisco, Cal.

Dealing with business-data processing, this book requires no previous knowledge of electronic computing systems or computer programming and systems analysis. The book was originally written as an automatic data processing systems program for the education of top management. For this reason the authors blend a theoretical and practical approach to data processing to explain the why and the what and the how of this field. Readers with varied interests can start at various places in this book with no loss of information or usefulness.

Instrumentation in Scientific Research Electrical Input Transducers

Kurt S. Lion
324 pages, $9.50
McGraw-Hill Book Co.
330 W. 42nd St., N.Y. 36, N.Y.

Prof. Lion presents a reasonably complete collection of existing basic methods and systems used as input transducers in electrical instrumentation. The book is more than just a collection of unrelated facts and figures. He has established order in a vast field of experimental methodology and instrumentation and provides an organization that permits logical and simple grouping of the numerous varieties of methods and systems functioning as input transducers. Each case contains the necessary mathematics coupled to a simple description of the physical mechanisms underlying each method.

Prof. Lion covers ranges of units within the families of mechanical input transducers, temperature transducers, magnetic transducers, electrical transducers and radiation transducers.

This is the first book we know of solely devoted to transducers in such detail. Users and designers of transducers or systems using transducers will find that this reference book will minimize their searches for literature or information on particular methods of achieving results based on transducers as well as determining the criteria by which the relative merits of existing methods and systems can be evaluated. This is a book that will be well fingered by the staff of E.M.D.

Classification of Electron Tubes

J. Haantjes and H. Carter
100 pages plus 2 tipped-in charts, printed in the Netherlands $3.50
Macmillan Co.,
60 Fifth Ave., N. Y. 11, N.Y.

The field of applied electronics is so wide and the variety of electron tubes so great that even professional electronic engineers find it difficult to keep well informed about developments within the field and with every member of the vast family of "odes" starting with the diode and currently reaching to the octode. Complicating this situation is the large family of "trons" including klystrons, magnetrons and ignitrons—to mention but a few. Finding your way unaided through the labyrinth of "odes" and "trons" is becoming well nigh impossible.

"Classification of Electron Tubes" has for its object the clarification of some of these problems. And it does perform this objective not only with clarity, conciseness and organization, but with some of the most beautiful illustrations that have ever appeared in a technical book of any kind. It starts out with a brief and simple account of the principal phenomena on which the operation of electron tubes is based, and continues with a system of classifying electron tubes, emphasizing their mutual relationships.

Various kinds of tubes are diagrammatically illustrated with brief descriptions of the more important types. This information is supplemented by cutaway views of typical tubes and with an alphabetical list containing short descriptions of the principal members of the family of "odes" and "trons" and ends with a comprehensive list of applications of electron tubes.

Controlled Rectifier Manual

255 pages, $1.00
General Electric Co., Semiconductor Products Dept.
Charles Bldg., Liverpool, N.Y.

S. W. Gutzwiller, D. V. Jones, H. R. Lowry, T. P. Sylvan and E. E. Van Zastrow of GE's Application Engineering have come up with a handbook on controlled rectifiers that is indeed a contribution to circuit designers utilizing this particular component. The material is as complete as it can be in the theory and application. And without any doubt, it is a tremendous contribution to the better understanding of silicon controlled rectifiers. If your design work involves these units, you can't spend a buck in a better way.

New Electromechanical Components For Electromechanical Systems

Multi-Turn Pot

Containing a continuous slide wire resistance element, multi-turn potentiometers combine the advantages of wire with high resolution. Resistance tolerance on a standard unit is 10% and linearity tolerance is 0.5%. Power figure is 5 watts at 40 C derated to 0 at 100 C. The 2.6 oz. pot operates from −55 C with resistance from 2 to 35 ohms. International Resistance Co., Phila., Pa.

Write No. 458 in Box on Inquiry Card

Wattmeter

Main elements of an ac-dc wattmeter are a locking contact meter-relay and a magnetic circuit built around a Hall effect solid state device. Capable of both indicating and controlling power in the lower milliwatt range, the unit also is available in modified form as a true r.m.s. voltmeter or ammeter, or as a varmeter. The instrument can monitor the product of as many as four different variables. Assembly Products, Inc., Chesterland, Ohio.

Write No. 313 in Box on Inquiry Card

Clutch and Brake Motors

Positive clutch and brake will start the output shaft of 40 and 80 in.-oz. synchronous motors in 10 milliseconds or less and stop a 1 rpm shaft within 1/10th degree. The brake will hold the maximum load from reversing the gear train. Two dished spur gears achieve instantaneous clutch action. Hurst Mfg. Corp., Princeton, Ind.

Write No. 460 in Box on Inquiry Card

Angular Position Transducers

Providing continuous and accurate measurement of angular displacement, small lightweight transducers have primary test application in servo systems on aircraft control surfaces, valve positioners and radar scanners of limited travel. Strain gages, electrically connected to form a balanced Wheatstone bridge, are bonded to a high strength metal beam forming the internal element of the device. Units are available in three ranges of ±30°, ±20° and ±00° and can operate on ac or dc with internal stops to prevent damage from overloads. Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div., Waltham, Mass.

Write No. 312 in Box on Inquiry Card

Fans

Belted axial flow fans were developed to simplify the frequent altering of ventilation systems. A bearing assembly for loads to 50 hp is furnished with each fan, regardless of initial hp ordered and a universal motor mounting plate, pre-drilled for all motor frame sizes is available on all fans so that capacity may be readily altered. Units operate in temperatures up to 350 F and for higher temperatures special lubricable bearings can be provided. Robbins & Myers, Inc., Springfield, Ohio.

Write No. 320 in Box on Inquiry Card

Pressure Transducers

Able to withstand overpressures of 1500 psi without shift or damage, transducers have a sensor design that requires no auxiliary cut-off valving arrangement. Pressure range is from 0-25 to 0-300 psi. Units measure 2¾″ X 3″ and are available with potentiometric outputs. White Avionics Corp., Long Island, N.Y.

Write No. 321 in Box on Inquiry Card

Temperature Control

Compact, remote bulb, indicating temperature control combines accuracy and sensitivity over ranges from 100 to 1000 F. Easy reference between the setting and controlling temperatures is provided by a single scale with two pointers. Unit may be set to control and indicate anywhere within scale limits and calibration is easily checked. United Electric Controls Co., Watertown, Mass.

Write No. 410 in Box on Inquiry Card

Printed Circuit Connector

Known as the Varitwin-Pin because of its twin taper-pin wire terminations, a printed circuit connector offers fork-like contacts with four coined mating surfaces resulting in high contact reliability and low contact resistance. The one-piece molded insulator of glass-filled diallyl phthalate incorporates board guides for easy mounting. Polarization of the 24 contact units may be utilized in one or more of eleven positions by insertion of a polyethylene polarizing tab; a corresponding slot having been milled or stamped in the printed circuit module card. Elco Corp., Philadelphia, Pa.

Write No. 317 in Box on Inquiry Card

Trimmer Potentiometer

Contact mechanism in a trimmer potentiometer is a stable Mil-R-94 type carbon element. Long spring arms provide adequate spring range in limited space. Twenty-five turn lead screw with clutch stops or an 18 turn lead screw with fixed stops are available. Power rating is 0.2 watt at 70 C with maximum operation up to 125C. Resistance range is 500 ohms through 1 megohm (linear taper). CTS Corp., Elkhart, Ind.

Write No. 369 in Box on Inquiry Card

Thermal Timer

With two terminals for both the contact circuit and the heater circuit, completely-housed thermal timers can be provided with normally opened or closed contacts with settings up to 2 minutes. Contact rating is 100 watts, 115 volts ac non-inductive load and the heater winding is rated at 24 volts. George Ulanet Co., Newark, N.J.

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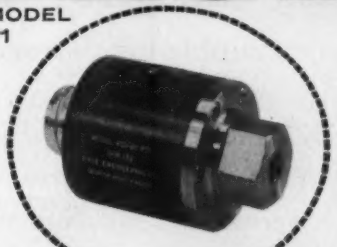
PACE

MODEL P1



magnetic reluctance

PRESSURE TRANSDUCER

Ranges: 0.1 to 1,000 psi — Gage, Differential and Absolute.

Pressure Media: Corrosive liquids or gases, both sides.

Withstands Extreme Pressure Overload.

Insensitive to Shock and Vibration — Not oil filled.

PACE's Model P1 is designed for low and medium pressure applications of laboratory accuracy.

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NEW

STEPPING SWITCH

COMAR
TYPE ACS

- Economical
- Compact Size
- Easily Mounted

Designed for sequence controlling, counting, totalizing, scanning and information storage. Modifications available for a variety of switching applications.

SPECIFICATIONS: Operating voltage up to 230 V.A.C.; Voltage range, −15% to +10% of rated voltage; Operating speed, 300 ppm.; Nominal power, 20 volt-amperes A.C. minimum; Contact combinations available, 2, 3, 4, 8 or 12 single pole continuous rotation, for shorting or non-shorting steps; Rating, 1 ampere at 115 V.A.C.; Insulation tested at 1000 V.R.M.S.; Impregnation to specifications.

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RELAYS • SOLENOIDS • COILS • SWITCHES • HERMETIC SEALING

CIRCLE NO. 55 ON INQUIRY CARD

ELECTROMECHANICAL COMPONENTS

Miniature Switch

Equipped with an overtravel plunger for cam actuation in rotary applications, a miniature switch has electrical and environmental characteristics which meet the requirements of MS-25085. Unit is 25/32″ long, ¼″ thick and .871″ high and operating specs include overtravel of 0.060″ minimum, pretravel of 0.015″ maximum and operating force of 10 oz. maximum. Return force is 1 oz. minimum and movement differential 0.001″ maximum. P. R. Mallory & Co., Inc., Indianapolis, Ind.

Write No. 427 in Box on Inquiry Card

Servo Repeater

Subminiature servo repeater includes gear train, motor-tach, control transformer, transistorized amplifier and power supply. Performance characteristics include zero backlash between the synchro control transformer and output shaft, static accuracy of 0.25 degrees maximum at a 7 minute synchro input, a velocity constant of 500 degrees per second per degree and a slew velocity of 30 rpm. Designed for low cost industrial and military applications, the repeater meets Mil E-5272 B. Input of 115 volt, 400 cps. at 7 v.a. and a size 8, 26 volt synchro transmitter is required. Orbit Instrument Corp., Syosset, N.Y.

Write No. 428 in Box on Inquiry Card

Rotary Thumbwheel Switch

Multi-deck 2, 10 or 12-position thumbwheel switches consist of any combination of binary and digital rotary modules manually operated by a single ¾″ black Delrin thumbwheel. Instant, accurate readability is provided by exposing only one large clear white or red number at a time through a bezel opening. Contacts are precious metal alloy and mounting frames corrosion-protected aluminum. Chicago Dynamic Ind., Inc., Chicago, Ill.

Write No. 452 in Box on Inquiry Card

Delay Timer

Hermetically-sealed automatic reset delay timers, specifically designed for extreme ambient conditions, meet applicable mil specs. Time cycles are one second to 60 hours and switch rating is five amps at 115/60. Industrial Timer Corp., Newark, N.J.

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REACTIVE METALS, REACTIVE METAL ALLOYS AND COMPOUNDS SUCH AS Zr, Hf, Nb, Mo, Ta, Be, V, Y, Th and U • Hi-purity powders (80-325 Mesh) • Compacts • Parts Fabrication and Welding • COATED PARTICLES AND COATED PARTICLE COMPACTS WITH COATINGS SUCH AS Nb, Ni, Cr, W, Mo, Cu, IN THE THICKNESS RANGE OF 2-35 MICRONS • CERAMIC AND CERMET SHAPES SUCH AS THERMAL SHOCK RESISTANT ROCKET NOZZLES • VACUUM ARC MELTING—INGOTS OF Zr Be, Ta, W • RESEARC i AND DEVELOPMENT; CONSULTATION ON MATERIALS PROBLEMS

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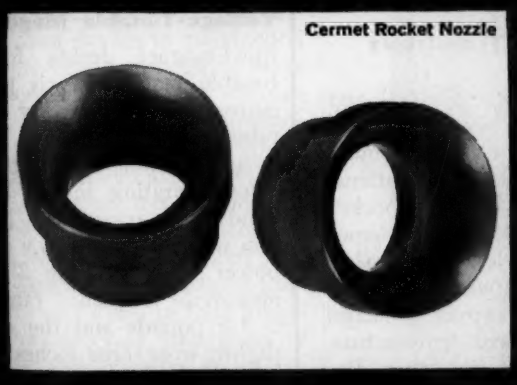
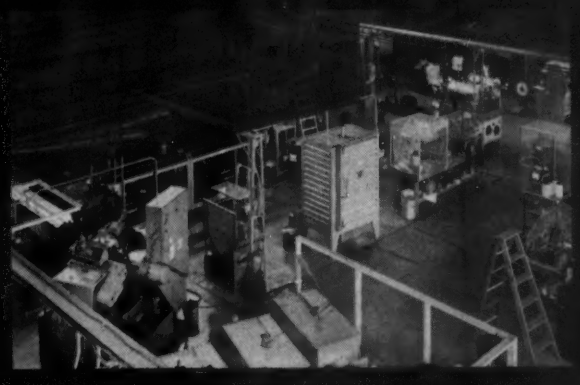


Cermet Rocket Nozzle



CIRCLE NO. 56 ON INQUIRY CARD

put HEINZE in your designs

HEINZE BLOWER-HEATERS

for WARMING and DRYING

Heinze Blower-Heaters provide continuous operation on applications such as hot food vending machines; photographic dryers; plate and food warmers. Heater wattages are available in single ratings from 200 to 1200 watts. Heater can be thermostatically controlled through separate terminals. Coiled wire heating element is well insulated to protect outer walls.

DH model includes Type D 2 pole shaded pole induction motor. YH model is powered by Type Y 4 pole shaded pole induction motor. Single units deliver 55 cfm; double units, 100 cfm. Motors are cw or ccw, 115V or 220V, 60 cycle, 1 ph. Choice of mountings.

Send coupon for complete technical data.

HEINZE ELECTRIC COMPANY
685 Lawrence Street, Lowell, Mass.
SUB-FRACTIONAL HORSEPOWER MOTORS AND BLOWERS

Heinze Electric Company, Dep't ED
685 Lawrence Street, Lowell, Mass.

Please send me literature and prices on Heinze Blower-Heater.

Name & Title.....

Company.....

Street & No.....

City & State.....

CIRCLE NO. 57 ON INQUIRY CARD

New Electronic Components For Electromechanical Systems

Band-Pass Filter

Narrow band-pass selective filter operates over a range from 1.0 to 10,000 cps. Frequency is selected by digital selection using a set of four dials. A three position gain selector switch permits gain settings of either −20 db, 0 db, or +20 db. Maximum selectivity is ±2.3% to the 3 db down points. Unit offers 38 db rejection to 3rd harmonic with a maximum attenuation rate near the center frequency of 250 db/octave. Dytronics Co., Columbus, Ohio.

Write No. 453 in Box on Inquiry Card

Constant Voltage Transformer

Sine wave (7% distortion) transformer's output remains constant to within ± 1½" with a line variation of 95 to 130V. Current-limiting feature prevents excessive fault currents. Unit can replace nonregulating transformers in step-up or step-down service and is hermetically sealed for application at elevated temperatures. Freed Transformer Co., Inc., Brooklyn, N.Y.

Write No. 330 in Box on Inquiry Card

Printed Circuit Resistors

Miniature wire-wound resistors, base mounted with two parallel leads, need only an area equal to their circumference for mounting purposes making them especially suitable to meet power requirements in printed circuits. Silicone coating maintains stable performance under adverse environmental conditions. Units are available in 4 wattages, 3, 5, 7 and 10, and in 5 sizes ranging from 9/16" x 3/16 to 1-25/32 x 3/8". Tolerance range is from 0.05% to 3% and resistance ranges from 0.05 to 175K ohms. Dale Products, Columbus, Nebraska.

Write No. 407 in Box on Inquiry Card

160 mc Power Mesa Transistors

Two Mesa transistors, the 2N1561 and 2N1562, producing ½ watt power at 160 mc are designed for high power output amplifiers in VHF applications. They can be used in two-way pocket radios, sonobuoy transmitters, telemetering and similar devices. Possessing a collector current capability of 500 ma, the cold-welded copper package insures very low internal temperature gradients. With a heat sink, they dissipate up to 3 watts at 25C case temperature and meet Mil-S-19500 specs. Motorola Inc., Phoenix, Ariz.

Write No. 416 in Box on Inquiry Card

Time Code Generator

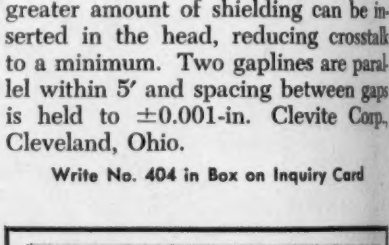
Time correlation of data recorded by various instruments is accomplished by a solid state time code generator. Two outputs are in dc level shift and modulated 1000 cps carrier form. Thirty-six-bit code indicates time of day and day of year and is read out once per second at a 100 pps rate. Unit employs a "leap year switch" to provide for the extra day every four years for long duration timing programs. Elec. Engr. Co., Santa Ana, Calif.

Write No. 448 in Box on Inquiry Card

Magnetic Heads

Integral interlace magnetic heads provide more efficient use of tape and maintain critical relative azimuth and spacing between two gap lines. The interlace construction nearly doubles the number of channels which can be recorded on a given tape width. Higher signal-to-noise ratio is attained due to the wider track or increased winding made possible by interlacing and a greater amount of shielding can be inserted in the head, reducing crosstalk to a minimum. Two gaplines are parallel within 5′ and spacing between gaps is held to ±0.001-in. Clevite Corp., Cleveland, Ohio.

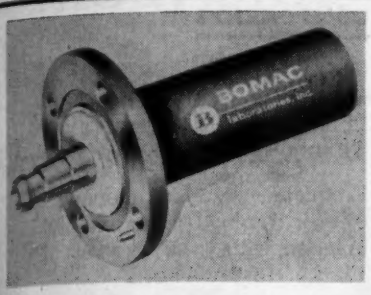
Write No. 404 in Box on Inquiry Card



Voltage-Tunable Magnetrons

Bowl-magnet design for voltage-tunable magnetrons is part of the current trend to smaller and lighter tubes. It can presently be applied to any of General Electric's magnetrons operating in S-, L- and X-bands. An example is the Z-5337 vtm which operates as a complete rf power source in the 2900-to-3100 megacycle frequency range. Weight is 1.5 pounds and the diameter is slightly over three inches and height is less than one inch. Tuning rate is 2.6 megacycles per volt. General Electric Co., Schenectady, N.Y.

Write No. 542 in Box on Inquiry Card



Coaxial Load

For use with balanced duplexers in radar systems, a coaxial load in 1⅝" 50 ohm EIA line, can dissipate an average power of 20 watts at 20 KW peak. Unit provides a maximum VSWR of 1.2 over a range of 400-450 mc. Designed as an expendable component, it is being sold at a relatively low price. Bomac Labs, Inc., Beverly, Mass.

Write No. 341 in Box on Inquiry Card

Power Transistor

Silicon transistor has a high frequency current gain of a minimum of four at six megacycles and also a dc current gain of 45 at one amp. Designated 2N1660, the unit has a power output of 85 watts and operates within a temperature range of 65 to 200 C. Raytheon, Semiconductor Div., Waltham, Mas.

Write No. 339 in Box on Inquiry Card

Micrometer Reference Transformer

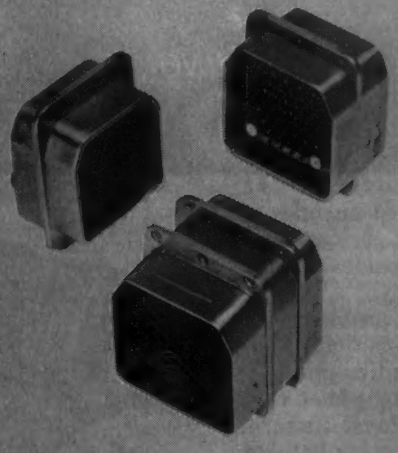
Zero suppression of all or part of a primary signal can be accomplished with a micrometer reference transformer. Designed for incorporating into a circuit using linear variable differential transformers, the unit can be used as a zero adjust or zero suppression device allowing sections or portions of an input signal to be expanded to read full scale, thus permitting more critical examinations of basic parameters. The instrument may also be used as a control point setting device, calibrated to operate at any desired value of an input variable, and as a null-balance device in conjunction with a vacuum tube voltmeter to make a simple manual null-balance measuring system. The micrometer reference transformer consists of a small aluminum frame and a micrometer anvil rod to which is mounted the core of the linear variable differential transformer. Transformer assembly is mounted in a phenolic block which is adjustable relative to the frame. Units include necessary dials for accurate indication of shaft position and transformer adjustment. Schaevitz Engrg. Co., Pennsauken, N.J.

Write No. 517 in Box on Inquiry Card

CIRCLE NO. 58 ON INQUIRY CARD→

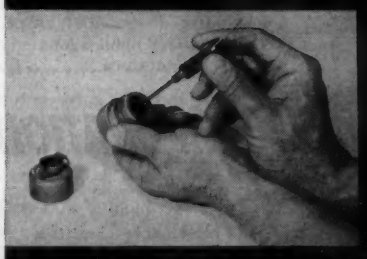
THIS IS YOUR FIRST LOOK AT CEC'S TWO NEWEST CONNECTORS

HIGH-ENVIRONMENT CIRCULAR TYPE designed to meet MIL-C-26500. This is CEC Series 600, 700, 800 for critical altitude, temperature, and reliability requirements of high-performance aircraft, missiles, and space vehicles. Resilient silicon-rubber seals provide liquid immersion resistant assembly. Available with 24, 31, and 55 removable, crimp-type contacts and choice of square flange or jam-nut receptacle mounting. Write for Bulletin CEC 4005-X2.



RACK AND PANEL RECTANGULAR TYPE with die-cast aluminum shell. CEC 500L Series with crimp-type contacts designed to meet MIL-C-26636. Available in 48- and 63-contact configurations with sizes 16 and 20 contacts. Two standard RG58/U coaxial contacts are included in the 48-contact connector. Insulator blocks of both new connectors are high-strength, glass-filled Diallyl Phthalate. Write for Bulletin CEC 4006-X2.

CEC also manufactures a full line of rectangular connectors (Series 500C) which feature snap-in, crimp-type contacts. This series is available in a wide variety of mounting configurations with 26 to 104 contacts. Write for Bulletin CEC 4004-X26.



A complete line of accessory tools for easy crimping, insertion, and removal of contacts is available.

Electro Mechanical Instrument Division

CEC

CONSOLIDATED ELECTRODYNAMICS / pasadena, california

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WHAT IF YOU GET NO WARNING UNDER SHOCK?

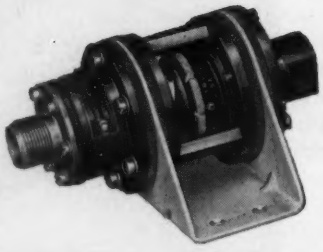
Vibration is one of the cruelest enemies of pressure switches. The unit that performed so well in the lab can have its insides shaken apart when the cps hit 2,000.

The only sure way to lick the problem is to run a pressure switch through tests that duplicate every known operating requirement.

Take Model 6885 shown at right that can, among other things, operate relays. Integral vibration isolation between mounting bracket and switch body makes possible exceptional performance under shock and vibration. At vibration levels through 2,000 cps, it has a burst pressure up to 7,500 psi in temperatures from −75°F. to 250°F. Its accuracy is ±4% at 800 psi actuating range under *all* conditions. It weighs only 10 oz., measures $3\frac{3}{8}$" to $4\frac{3}{8}$".

Do it yourself. Take one of our Model 6885 units and run it through six weeks of testing as we did.

Or save six weeks by asking for our test data on a full line of pressure switches and choose the units that fit your needs best. Call Mr. Charles Colt at Consolidated Controls, Bethel, Conn. Phone Pioneer 3-6721.



Inches of Water to Hundreds of Atmospheres

Model 6885 shown above is one of more than 300 pressure switches available from Consolidated Controls for missile, aircraft and nuclear applications. Working pressures range from 10" of water to 10,000 psi at ambient temperatures from −65°F to 1000°F. Standard models for

- high vibration
- differential pressures
- hydraulic
- miniaturized applications
- high temperature

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A Member of The Condec Group

BETHEL, CONNECTICUT
INGLEWOOD, CALIFORNIA

CIRCLE NO. 59 ON INQUIRY CARD

ELECTRONIC COMPONENTS

Tuning Fork Oscillator

Frequency standard employs a piezoelectric tuning fork assembly in conjunction with a highly efficient driving circuit. Instrument is complete with power supply for operation from 115 volt, 60 cps line. Accuracy is ±0.1% at 25 C. Industrial Test Equipment Co., New York, N.Y.

Write No. 340 in Box on Inquiry Card

Impedance Comparator

Impedance-measuring system compares a resistor, capacitor or inductor with a standard sample, indicating directly on panel meters the magnitude and deviation of impedance difference and phase-angle difference between them. The instrument consists of a signal source, a bridge and detecting circuit. Accuracy is 3% of the full-scale value, thus impedance difference can be measured to ±0.003% on the most sensitive range and phase-angle difference to 0.00003 radian. General Radio Co., West Concord, Mass.

Write No. 402 in Box on Inquiry Card

Hi-Speed Magnetic Memories

Making use of thin magnetic films, memory units consist of glass rods 0.010 in. in dia., electro-plated with a magnetic alloy and wound with many small coils. Packages can contain 768 bits or other capacities; several small units may be combined into a modular system. Complete read-write cycle, including access time, requires only one microsecond; units have been built to operate with a 0.5 microsecond cycle. One intended to operate in 0.25 microsecond is being developed. The rod elements operate over a temperature range of −100 to +200 C without appreciable change in switching characteristics. Nat. Cash Register Co., Hawthorne, Calif.

Write No. 510 in Box on Inquiry Card

Silicon Mesa Transistor

Designated EIA 2N752, general purpose mesa transistors developed for all small signal applications to 200 mc, are recommended for severe environmental conditions. Units exhibit high gain at collector–emitter currents up to 100 ma. Dissipation is 300 mw in free air, leakage current is five microamps at +150C and collector-base capacitance 5μ. National Semiconductor Corp., Danbury, Conn.

Write No. 300 in Box on Inquiry Card

Announcing a new series of **size 8 servo components** designed for today's high performance systems

hi-*T* or lo-*J*

(HIGH TORQUE) (LOW INERTIA)

EAD's new line of Size 8 servo components are designed to meet the extreme environmental conditions and the reliability required by today's advanced control systems. From a family of six basic units, the design engineer has the selection of servo motors, inertially damped servo motors or servo motors with tachometer generators for "hi-*T*" or "lo-*J*" system needs.

As with all EAD components, these motors can be modified, if necessary, and can be supplied with a wide variety of integral gear reductions.

TYPICAL CHARACTERISTICS

- **26 volts per phase, 400 cycles**
- **Stall power per phase (watts):**
  - **hi-T 3.0**
  - **lo-J 2.8**
- **Max. power output (watts):**
  - **hi-T .40**
  - **lo-J .28**
- **Size 8 diameter: .750"**
- **Meets MIL-E-5272, MIL-E-5400.**
- **Ambient temperature: —55°C to +125°C.**

Construction features: precision ball bearings, housing and hardened shaft all of stainless steel.

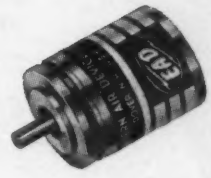
SERVO MOTORS

hi-*T*

Embraces high torque/watt ratio and adequate acceleration characteristics. Stall Torque, .35 oz-in.; Rotor inertia, .66 gm.-cm²; Acceleration, 37,000 rad./sec.²; No load speed, 6500 rpm; Damping coefficient, 36 dyne-cm-sec/rad.; 3.0 watts/phase @ stall.

lo-*J*

For low time constant and fast response to input signals in systems requiring max. torque/inertia. Rotor inertia, .17 gm.-cm²; Acceleration, 104,000 rad./sec.²; No load speed, 6500 rpm; Damping coefficient, 26 dyne-cm-sec/rad. Stall torque, .25 oz-in.



SERVO MOTORS with TACHOMETER GENERATORS

hi-*T*

Stall Torque, .35 oz-in.; Rotor inertia, .72 gm.-cm²; Acceleration, 34,400 rad./sec.²; No load speed, 6200 rpm; Damping coefficient, 38 dyne-cm-sec/rad.; 3.0 watts/phase @ stall; Gen. output, .250 v/1000 rpm; Phase shift, ±10°; Null voltage, 10 mv.; Gen. input, 1.7 watts.

lo-*J*

Rotor inertia, .23 gm.-cm²; Acceleration, 77,000 rad./sec.²; No load speed, 6200 rpm; Damping coefficient, 27 dyne-cm-sec/rad.; Gen. output, .250 v/1000 rpm; Phase shift, ±10°; Null voltage, 10 mv.; Gen. input, 1.7 watts. Stall torque, .25 oz-in.

SERVO MOTORS with INERTIAL DAMPERS

hi-*T*

Stall torque, .35 oz-in.; Rotor inertia, 1.0 gm.-cm.²; Acceleration, 24,700 rad./sec.²; No load speed, 6000 rpm; Damping coefficient, 39 dyne-cm-sec/rad.; 3.0 watts/phase @ stall; Flywheel damping, 60 dyne-cm-sec/rad.; Corner freq., .98, 2.8 and 18.5 cps.

lo-*J*

Rotor inertia, .54 gm-cm²; Acceleration, 32,700 rad./sec.²; No load speed, 6000 rpm; Damping coefficient, 28 dyne-cm-sec/rad.; Flywheel damping, 60 dyne-cm-sec/rad.; Corner freq., .77, 2.8 and 16.4 cps. Stall torque, .25 oz-in.

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EASTERN AIR DEVICES, INC.

SUBSIDIARY OF NORBUTE CORPORATION

353 CENTRAL AVENUE, DOVER, NEW HAMPSHIRE

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Temperature Controls for Industrial, Aircraft, Marine, Special Purpose

APPLICATIONS: Unlimited. For 28 years, we have been designing and manufacturing controls to fit individual needs.

MEDIUM: Air, liquid or hotplate.

RANGE: −150 to +650°F, adjustable.

SENSITIVITY: ±.5°F and up.

SWITCHES: Normally closed, open or double throw. Manual reset, high ambient and others available. 15 or 20 amps. 115/250 Volts AC. Also DC.

TYPES: Local mounted, remote bulb, skeleton or enclosed, calibrated or uncalibrated, single or multi-switch, indicating, explosion-proof, minimum size and special purpose.

OPERATION: Precision-made, liquid filled bellows combine with full rated snap-action switches for quick, accurate response to temperature change.

For further information request Condensed Catalog #400.

UNITED ELECTRIC

CONTROLS COMPANY

88 School St., Watertown, Mass.

CIRCLE NO. 65 ON INQUIRY CARD

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"Monoball"®

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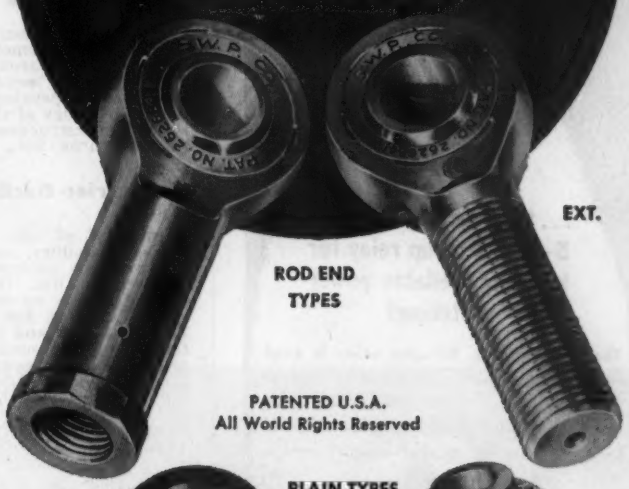

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ROD END TYPES

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PLAIN TYPES

CHARACTERISTICS

	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Alloy Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Steel Ball	For types operating under normal loads with minimum friction requirements.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for Engineering Manual No. 551. Address Dept. EMD-60

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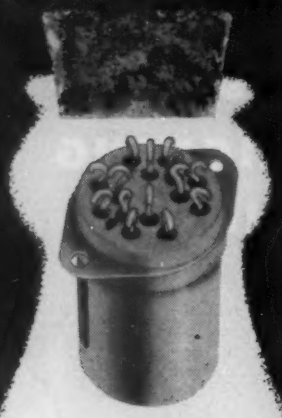
1705 SO. MOUNTAIN AVE., MONROVIA, CALIFORNIA

CIRCLE NO. 66 ON INQUIRY CARD

POWER SWITCHING A BOTTLENECK?



...then specify the new S-316, 10 amp relay for long-life, reliable power switching!

The Series S-316, 10 amp relay is engineered for long-life—designed to operate for more than 2,000,000 cycles—with reliable power switching operations in aircraft, missiles, ground-support equipment, and wide industrial applications demanding true performance.

This new power switching relay is another development in U.S. Relay-Electronics' complete line of quality relays and packaged-circuit controls—tailored to meet your exacting requirements.

Check (✓) these features:

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- ✓ Temperature range: —70°C to +120°C
- ✓ Choice of enclosure and mounting styles
- ✓ Maximum weight: 4.64 ounces
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Excellent for use in corrosive and other severe industrial environments.

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CIRCLE NO. 48 ON INQUIRY CARD

For Your 3-Ring Binder

NEW DATA SHEETS

For your free copy of the data sheets listed on this page, enter the appropriate number of the item on the Inquiry Card.

Potentiometers 521

Four page summary brochure on leadscrew actuated potentiometers summarizes key information on sixteen standard models including resistances, terminal types, power ratings, operating temperatures and dimensions. Cut-away drawings of three models illustrate the internal construction and show design features. Bourns, Inc., Riverside, Calif.

Subcarrier Oscillator 385

Consisting of an electronic commutator, carrier amplifier, subcarrier oscillator, and discriminator network, solid state telemetry band unit has the following important characteristics: no warm up time; an overall system drift as low as ±0.5 percent over a 24 hour period and a wide temperature range for a five volt input level; a signal linearity of less than ±0.5 percent; the practical utilization of an unregulated power source—a variation of power supply voltage of 10 percent will produce less than a 0.05 percent frequency change. Solidtronics Div., Electrosolids Corp., Van Nuys, Cal.

Fusion Sealed Resistor 384

Made by fusing a metallic-oxide film into the surface of glass rod, then encapsulating the assembly in glass, a glass-enclosed resistor defies absorption and has high resistance to damage from vibration. ⅛-watt and ¼-watt resistors which exceed performance requirements of MIL-R-10509C, Characteristic B, have resistance range of 100 ohms to 360K ohms, voltage rating of 250 and 300 v. Corning Electronic Components, Corning Glass Works, Bradford, Pa.

Fastener 571

Cam-Bolt, a special fastener, is designed for use where the strength of a bolt is required but where fast opening and closing is desirable. One simple adjustment at the time of installation insures a constant leak-proof seal of any predetermined pressure, thus eliminating the need for a torque wrench to insure uniform closing pressure. Simmons Fastener Corp., Albany, N.Y.

Gears 380

Designed to meet all industrial power drive requirements, stock and special gears, both 14½° and 20° pressure angle styles, are described in brochure which contains information on bevel, helical, miter, worm and spur gears as well as steel racks. The Ohio Gear Co., Cleveland, Ohio.

3-Way Valves 379

Three way valves for air, oil, water, gas, chemical or vacuum service have operating pressures of 0-250 psi, pipe sizes of ¼-1 inch. Bulletin describing these valves supplies specifications, ordering information, outstanding features and dimension. Airmatic Valve, Inc., Cleveland, Ohio.

Nuclear Instruments 425

Nine nuclear instruments now available are stable microammeter, high-voltage power supply, log-N period amplifier, log count rate meter, log count rate meter with period, linear count rate mdgdf, preamplifier, flux amplifier and actuator amplifier. These are described in 4-page bulletin along with a wide range of instrumentation system-design services. G.E., Schenectady, N.Y.

Spring Pins 572

Ten page technical data material defines and describes coil spring pins, called Spirol. Characteristics include uniform flexing compression and shock absorption. The pin coils conform radially with any shape hole and conform longitudinally with the hole wall throughout the pin length. C. E. M. Co., Danielson, Conn.

Speedomax H Range Conversion 374

A guide to selecting the necessary components—scale, chart, circuit panel, etc.—to change the range of any standard Speedomax H instrument, this bulletin contains a master table, listing the basic items required to change range (1) for the same type of primary element, or (2) from one type of primary element to another (e.g., thermocouple to Rayotube detector). Individual tables list the specific part numbers of scales, charts, etc. for each type of range. Wiring diagrams to simplify electrical connections are also listed. Leeds & Northrup Co., Philadelphia 44, Pa.

Unitized Modules 373

Basic electromechanical components are designed as modules and assembled in a unitized package. Packages may be composed of synchros, servo motors, magnetic clutches or brakes, spring return devices, commutator switches and precision potentiometers. Bulletin describes how the units provide miniature, light, reliable systems. Technology Instrument Corp., No. Hollywood, Cal.

High Temp Processing Problems 372

First in a series of high temperature applications bulletins offering industry detailed information on the use of ceramic tooling materials at elevated temperatures, this bulletin shows the typical application of a 2000F material in an RF soldering application where the material offers unique characteristics required in this type of high temperature process: high heat resistance, low thermal expansion rate, and non-wettability by molten solder alloys. Photo depicts a fixture arrangement for soldering a magnet assembly giving details on RF coil design, fastening and locating methods used. Duramic Prods., Inc., Palisades Park, N.J.

Miniature Ball Bearings 371

Junior catalog covers dimensional data, load factors, ball sizes and weights of sealed and open radial, flanged radial and pivot type miniature ball bearings in RBM line. An interesting feature is a listing of other leading manufacturers' catalog numbers, giving design engineers a means of knowing what manufacturer has bearings available to meet specific specs. Landis & Gyr, Inc., New York 36, N.Y.

Control Systems and Components 370

Developed as an aid to manufacturers considering automatic controls for the conversion of existing equipment and the control of new equipment, this folder contains information on point-to-point control systems, speed control systems, and fractional and integral horsepower servo systems as well as control system components. Seneca Falls Machine Co., Seneca Falls, N.Y.

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